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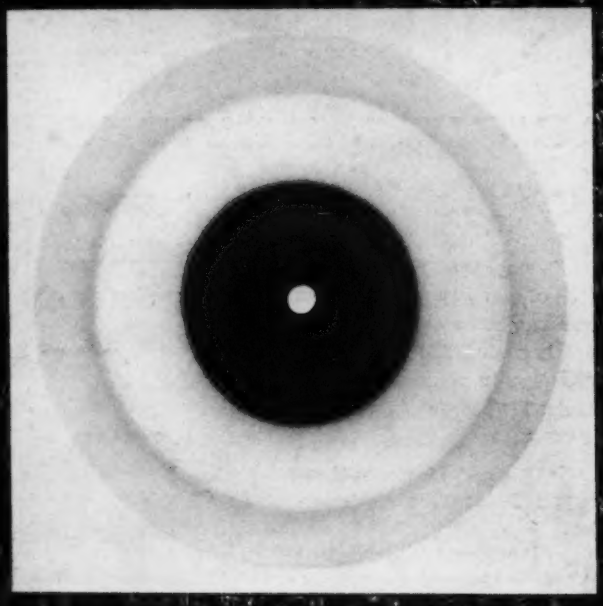
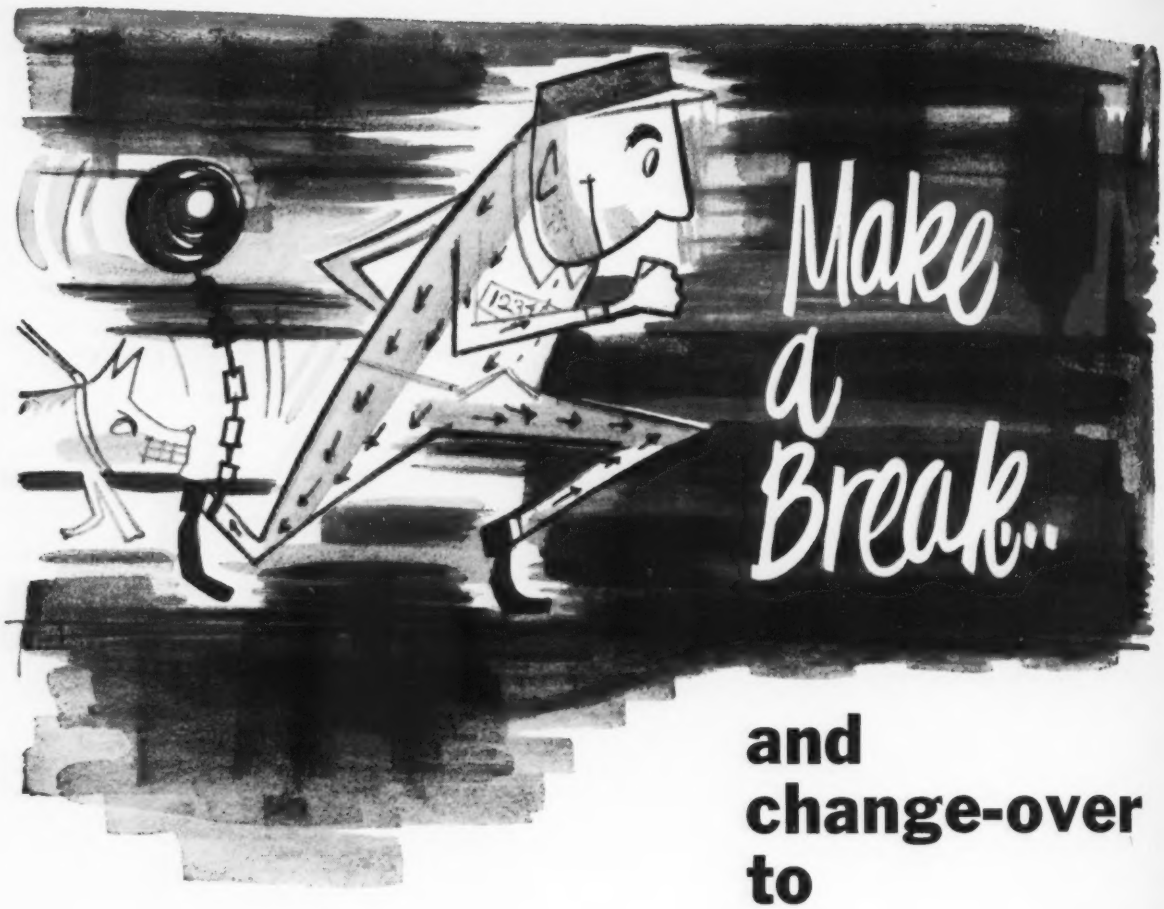
THE UNIVERSITY OF MICHIGAN



X-ray diffraction of carbon fibres

Progress with Refractory Fibres

page 418



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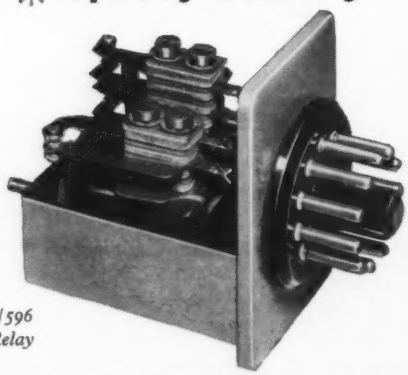

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Engineering Materials and Design

★ *The Magazine for Engineering Designers*

A HEYWOOD PUBLICATION

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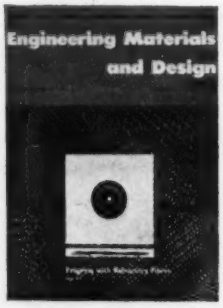

COVER: Graphite fibres and fabrics can be made in the same wide range of textures as are available in conventional textile forms. Four of the various types of graphite cloth being commercially produced are shown here.

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ISSUE AT A GLANCE

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PROGRESS WITH REFRACTORY FIBRES **418**

Discussion of some of the high-temperature insulating materials based on refractory fibres.

By C. Z. Carroll-Porczynski

FREEWHEELING DEVICES: PART 2 ... ... **430**

Concluding section of the survey of silent ratchets, freewheels, backstops and sprag clutches.

GLASS—ITS ROLE IN POWDER METALLURGY **439**

Dealing with various applications of sintering under glass.

By **D. Yarnton and D. K. Hill**

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Staedtler Scholarship for Draughtsmanship **442**

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Résumés

DISPOSITIFS DE ROUE LIBRE: 2ème partie page 430

Ce deuxième article sur les rochets silencieux, les roues libres et les embrayages à cales complète la description de la gamme d'éléments fournis par les principaux fabricants et marchands de Grande-Bretagne.

PROGRES DANS LE DOMAINE DES FIBRES REFRACTAIRES

par C. Z. Carroll-Porczynski page 418

L'auteur examine plusieurs matériaux isolants pour hautes températures et constitués de fibres réfractaires, dont certaines formes de Refrasil, de titanate de potassium, de graphite et de bioxyde de zirconium.

LE VERRE—SON ROLE DANS LA METALLURGIE AUX POUDRES

par D. Yarnton et D. K. Hill page 439

L'article décrit comment on peut employer le frittage sous verre pour produire des combinaisons de métal et de verre ayant des propriétés intéressantes, ou pour remplacer le frittage sous vide ou l'étampage à chaud sous vide de poudres libres ou de poudres de métal.

ECROUS STANDARD POUR BOULONS ET VIS JUSQU'A 2,8 cm DE DIAMETRE page 459

Kurzreferate

FREILAUFEINRICHTUNGEN: Teil 2 Seite 430

Diese abschliessende Übersicht über geräuscharme Sperräder, Freiläufe, Rück-an schläge und Keilkupplungen beendet die Beschreibung der von den hauptsächlichen Fabrikanten und Lieferanten in Grossbritannien erhältlichen Bauteile.

FORTSCHRITTE MIT FEURERFESTEN FASERN

von C. Z. Carroll-Porczynski Seite 418

Der Verfasser bespricht einige auf feuerfesten Fasern aufgebaute Hochtemperatur-Isolierstoffe, mit Einschluss der verschiedenen Formen von Refrasil, Kaliumtitanat, Graphit und Zirkondioxyd.

GLAS—SEINE ROLLE IN DER SINTERMETALLURGIE

von D. Yarnton und D. K. Hill Seite 439

Der Artikel beschreibt, wie Sintern unter Glas verwendet werden kann, um Glas-Metall-Kombinationen mit interessanten Eigenschaften herzustellen, oder um Alternativen für die Verfahren der Vakuumsinterung oder des Heisspressens von losen Pulvern oder von Pulver-Metall-Zusammenstellungen unter einem Vakuum zu finden.

STANDARDMUTTERN FÜR BOLZEN UND SCHRAUBEN BIS ZU DURCHMESSERN VON 2,8CM ø Seite 459

Резюме

МЕХАНИЗМЫ СВОБОДНОГО ХОДА — Часть 2-ая стр. 430

Эта заключительная часть обзора бесшумных рачек, свободного хода, остановок задним ходом и распорочной муфты сцепления завершает описание ассортимента компонентов, выпускаемых главными фабрикантами и поставщиками в этой области в Соединенном Королевстве.

УСПЕХИ В ОБЛАСТИ РАЗВИТИЯ ОГНЕУПОРНЫХ ВОЛОКОН

С. З. Карролл-Порчинский стр. 418

Автор обсуждает ряд изолирующих при высоких температурах матерьялов, в состав которых входят в качестве базы огнеупорные волокна, в том числе различные виды Рефразила, титанит калия, графита и двуокиси циркония.

РОЛЬ СТЕКЛА В ПОРОШКОВОЙ МЕТАЛЛУРГИИ

Д. Ярнтон и Д. К. Хилл стр. 439

Описывается, как можно использовать спекание под стеклом для производства смесей металл — стекло с интересными свойствами или-же в качестве альтернативы вакуумному спеканию и горячей вакуумной прессовке порошка или компактных прессовок порошка — металла.

СТАНДАРТНЫЕ ГАЙКИ ДЛЯ БОЛТОВ И ВИНТОВ ДО 2,8 см диаметра стр. 459

MATERIALS IN THE NEWS

Monthly Digest of Materials and Design News from Home and Abroad

Working Out π was a Piece of Cake

THAT AGE-OLD PROBLEM of schoolboys—the exact evaluation of the Greek symbol π, which is used to indicate the proportion of a circle's circumference to its diameter—was recently given a face-lift. Mr. N. D. Robinson, a mathematician at E.M.I. Electronics Ltd.'s Hayes laboratories, programmed an Emidec 1100 electronic computer to calculate the value of π. The computer worked it out to 10,880 decimal places—further, it is believed, than the calculation has ever been taken before. There was still a remainder, but it can be proved theoretically that π can never be worked out exactly.

The complete operation, which was undertaken as a machine reliability test, included 35 million separate calculations and occupied thirteen hours of computing time. The same task, done with pencil and paper, would occupy the average person for sixty-five years, working a forty-hour week and taking two weeks' annual holiday.

Note: Mr. W. Shanks calculated π to 530 decimal places in 1853. He continued his calculation to 707 places in 1873, but it was recently discovered that he had made an error around the 530th decimal place.

Superconducting Wire for Ultra High Magnetic Fields

RESEARCH SCIENTISTS at Bell Telephone Laboratories, in the U.S.A., have demonstrated the feasibility of superconducting solenoid magnets producing extremely high magnetic fields. They utilised a superconducting compound of niobium and tin (Nb_3Sn), fabricated and reacted by special metallurgical techniques, in their latest experiment.

Although it has been realised for many years that it is possible to produce magnetic fields with superconducting solenoids, the materials that have been tried in the past could only sustain fields of a few thousands gauss. At larger magnetic fields the superconducting properties disappeared. With the new compound, steady-state magnetic fields of 88,000 gauss are possible.

Additionally, a superconducting solenoid does not require expenditure of electric energy once the field is established, whereas a solenoid of ordinary metal uses large amounts of energy. Nb_3Sn becomes superconducting at 18 deg. Kelvin, a higher transition temperature than any other superconductor at present known. This compound was first discovered at Bell Telephone Laboratories in 1954. Up till now, however, its critical field had not been measured. Since it is extremely brittle, it has not been possible heretofore to use the niobium-tin compound in the construction of a solenoid (coil magnet).

Indications are that the niobium-tin material will sustain fields of 100,000 gauss while carrying electrical currents of 100,000 amps/sq. cm. of cross-section.

This new material development will have important applications wherever large volumes of magnetic fields are required. Important uses in the field of communications are envisaged. Many electronics devices require magnetic fields for their operation—among these are travelling wave tubes and masers. The availability of large magnetic fields can extend the operation of these devices to higher frequencies thus providing the possibility of broadband communication systems for use in earth-based radio-relay systems, and active satellite repeaters for space communications. Another attractive application is the containment of thermonuclear fusion plasmas for the production of electric power.

A third important use is in the experimental physics laboratory, where the cost of producing high magnetic fields has greatly limited the experimental physicist. The new materials discovery may make high fields available to a wider community of scientists throughout the world.

Another series of new alloys, made of molybdenum and technetium, was announced recently at the Spring Meeting of the American Physical Society by Dr. B. T. Matthias, of Bell Telephone Laboratories. (Technetium is a man-made element.) These new alloys, which are very ductile, become superconducting at temperatures near 16 deg. Kelvin.

Plastics-coated Steel

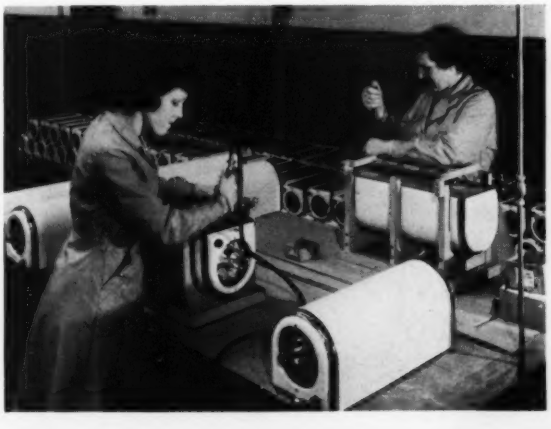
MOST DOMESTIC APPLIANCES are stove- or vitreous-enamelled and require several processes after fabrication. This, however, may be made a thing of the past by using a plastics-coated steel sheet, such as Stelvetite, developed by John Summers & Sons Ltd. of Shotton.

One company that is using the new steel, Aidas Electric Ltd., of Salisbury, has in fact been able to do away with its paint shop, save 17½ per cent on capital cost, and start production in a new factory three months sooner than would otherwise have been the case. The colour of Stelvetite is in the plastics sheet itself.

The laminate is produced by bonding vinyl sheet to high quality sheet steel, the obverse side being electro-zinc plated or hot-dip galvanised. Close quality-control during manufacture enables the sheet to be sheared, punched, formed, seamed, deep drawn, expanded and so on without damage to the coating, and without divorcing the vinyl from the steel base. The laminate will therefore do anything that the steel alone can do, and sometimes more.

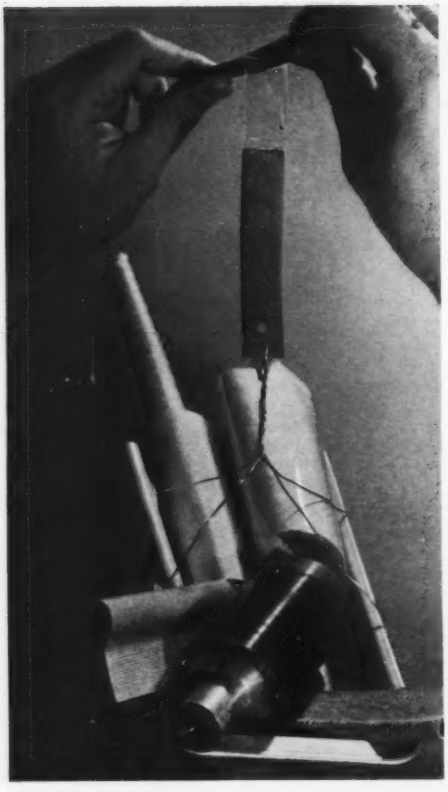
Stelvetite is a finished material, ready for fabrication. All the user has to do is fabricate it. Pre-treatment, painting, stoving and drying-out time (as with paints and lacquers) are not needed, yet the finish is permanent. This gives the engineer an opportunity to design in colour, and so add sales appeal to the product.

Final assembly of the new Sadia Twoplus electric water heater, which has an outer casing of Stelvetite plastics-coated steel.



PICTURE NEWS

IN THE WORLD OF MATERIALS & DESIGN



P.T.F.E. ADHESIVE

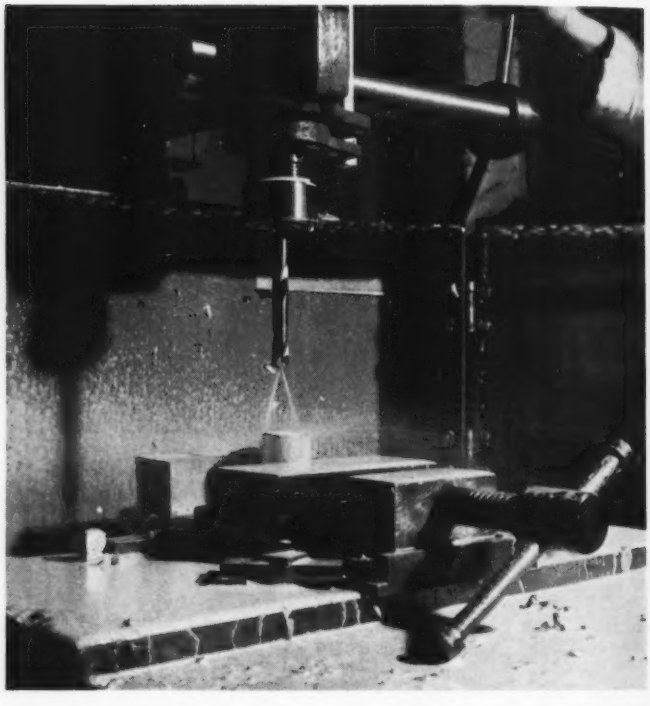
A new Du Pont process allows one surface of Teflon film to be fixed by adhesive to a variety of engineering materials as an anti-stick or protective coating. In the above illustration a piece of the new film bonded between metal strips is shown supporting the weight of an ice-tray loaded with other coated items.

NEW RAKE TEETH

The improved flexibility and durability of the new type of hay rake tooth shown below is due to a ball-joint socket of rubber which bonds the curved tooth to the mounting bracket. Made by Goodyear, of the U.S.A., this design is intended to obviate the frequent replacements necessary with all-steel models.

COLD-POINT DRILLING

This drill, available from Coldpoint Drills Ltd., has a fluted shank with a hard metal tip and a bore running through the centre with outlets at the extreme tip through which a coolant can be passed under high pressure. This keeps the cutting edges cool, and washes away the chips of metal which have been cut.



PRIVATE HOVERCRAFT

The first privately-built hovercraft, designed by a former test pilot and constructed in the aircraft workshops of the College of Aeronautical and Automobile Engineering, has been named the Skimmer by its designer Mr. Donald R. Robertson, who is shown below seated at the controls. The machine weighs 250 lb., and although really a single seater it can lift five men.

AIR-INHALING WINGS

A reduction of up to 80 per cent of drag caused by air friction is claimed to be possible with air-inhaling wings developed by the Northrop Corp. Laminar air-flow can be maintained over a large wing area by drawing the boundary layer air through fine slots and discharging it at the rear to obtain additional thrust.

FULL-SCALE IMPACT TEST

The left-hand picture, by Viking Marine Co. Ltd., shows a reinforced polyester resin rescue boat for the P. and O. liner *Canberra* undergoing a drop test from 30 ft. The hull remained intact, and the only damage—superficial—was to the alloy keel!

STAINLESS—A MATCH FOR CORROSION!

Very fine filters used in the petroleum industry are made from 18/9 chromium nickel austenitic stainless steel wire. A length of this 0.015-in. dia. wire is shown below wrapped round the head of an ordinary match. (Courtesy: *Steel Review*, and Samuel Fox and Co. Ltd.)

FLEXIBLE ABRASIVE SPONGE

The special cellular structure of this new finishing material by Artifex is said to reduce the number of operations needed to produce a high finish. The sponge (marketed by Finishing Aids and Tools Ltd.) is flexible, and will conform to curved and profiled surfaces.

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Commercial Thermoelectric Refrigeration

THE NORGE DIVISION of the Borg-Warner Corp. recently announced the introduction of the first commercial thermoelectric product on the U.S. market. This unit, which is a thermoelectric refrigerator-freezer, will first be used in 500 rooms of the new Sheraton-Chicago Hotel. It is to be produced in greater quantities for hotels, hospitals, doctors' surgeries and similar establishments.

The new unit uses Melcor thermoelectric modules made by Materials Electronic Products Corp. In the past few months this company has greatly increased its production capability, and is now capable of supplying up to 20,000 couples per day, which represents approximately 80,000 to 100,000 B.t.u./hr. of practical test pumping capacity, or approximately 2,000 cu. ft. of refrigeration. This puts the cost of the thermoelectric modules approximately in the £1 per cu. ft. range in refrigeration applications. All Melcor materials and modules have at present an effective Z factor in fabricated couples of 3×10^{-3} giving temperature drops of 73 to 77 deg. C. from 27 deg. C. in a vacuum.

New Design of Blast Furnace

THE MILLOM HEMATITE ORE AND IRON CO. LTD., producers of high-grade hematite pig iron and other special quality pig irons, recently put into operation at their works at Millom, Cumberland, a new blast furnace which incorporates certain unusual features of special interest to the iron and steel industry. The new furnace is mechanically charged under full automatic control and can consequently be charged by one man, against the nine or ten required with older, hand-charged furnaces.

With appropriate burden, the furnace has a production capacity of up to 800 tons of hematite pig iron per 24 hr., or about 5,500 tons a week. This, together with another blast furnace (3,500 tons weekly capacity) gives the works a possible output of 9,000 tons a week.

Special features of the new unit include an exclusive and economic design of stack columns arranged so that the whole of the top weight of the distribution and charging gear, together with the furnace top platform, is carried direct onto the main support columns instead of onto the stack casing. Since the cooler platforms are also carried on this structure, the arrangement involves very little extra steelwork than conventional cooler platform designs. Also, the stack plates are not as thick as they otherwise would have to be. The important aspect of this arrangement is that the whole stack is free to expand and, in the event of any fracture of the casing, the top weight—which is considerable in modern blast furnaces such as this—causes no danger. Individual plates or if necessary the whole stack, may be replaced safely without interference to the top gear.

The mechanical charger is of the contractors' standard double-bell revolving distributor type, but embodies a special feature which permits the splitting of the gas seal and rolling back of the distributor and receiving hopper to facilitate quick changing of the large bell. The stockline sounding rods are constantly in the furnace, except during main bell operation, and their movements are electrically transmitted to dial indicators and recorders, which give a constant indication and record of the stockline movements and of the time when each charge is dropped.

The design, supply and erection of the new furnace and ancillary plant was carried out by Wilfred Marley Ltd., of Workington.

General view of the new blast furnace at the Millom Hematite Ore and Iron Co.'s works in Cumberland, showing the unusual construction of the stack columns.

THE AUGUST ISSUE

of *Engineering Materials and Design* will include the following main features:

Survey of Pipe Couplings: Part I
Typical uses and limitations are described.

MoS_2 enhances Wear Resistance of Nylon
Description of how controlled amounts of molybdenum disulphide homogeneously dispersed in nylon allow parts to be produced at competitive cost.

Designing with Thermoplastics
Showing how engineering design techniques can be used to obtain optimum performance.

Gravity Diecasting of Aluminium Bronze
Stage by stage explanation of production in a foundry specialising in this class of work.

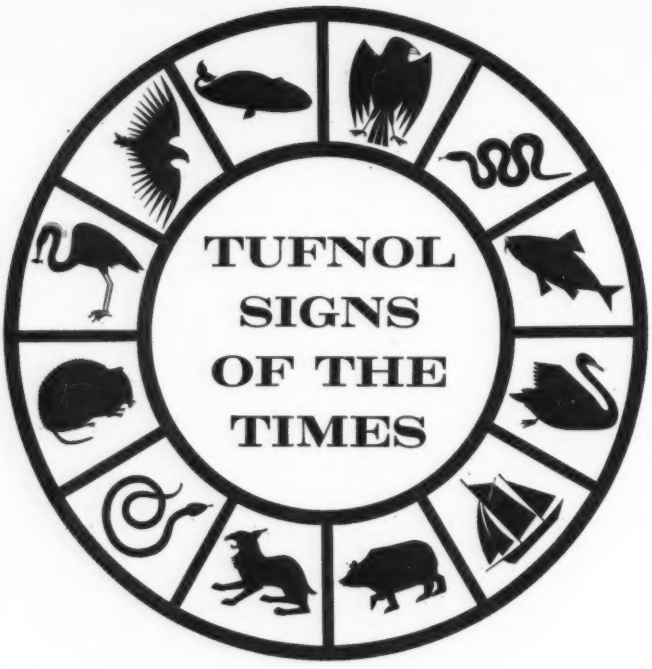
Engineering Materials and Design Association

FOLLOWING THE INTEREST aroused by *Engineering Materials and Design* (which led to the sponsorship of the first Engineering Materials and Design Conference and Exhibition, at Earls Court), and as a logical development to meet the obvious need for a designers' forum, an Engineering Materials and Design Association is planned. This will be open to engineers, designers and technicians, and others who have an interest or are associated with engineering.

The purpose of the Association will be to stimulate discussion on the practical interpretation of engineering design, to promote, encourage and improve design, and to foster and facilitate the interchange of ideas and practices by meetings, conferences, visits, social and international events.

Membership of this non-profit-making Association will cost 10s. per annum, and will entitle the member to participate in all relevant conferences and social events, a draft programme of which is being prepared. Interested readers are invited to write for details to the Hon. Secretary, c/o The Editor, *Engineering Materials and Design*. Alternatively, the "Reader Enquiry Card" may be used for this purpose.

A reception will be held during the week of the 2nd Engineering Materials and Design Conference and Exhibition, which is to open at Earls Court on November 13, 1961.



Whale-sign of Tufnol

Those people born under the sign of the Whale have something to spout about. They become chief purchasing officers, chief engineers, chief draughtsmen and chief designers. Whale men leave it to Jonah's disciples to wail about the inadequacies of the materials they have at hand. Whale men are perfectionists who travel far when they find one material that is light yet strong and hardwearing, resistant to corrosion and a good electrical insulator. They also find that this ideal material resists deterioration in storage, machines easily with ordinary tools, and is available in sheets, tubes, rods, angles, and channels. Many Whale men have already discovered this remarkable material—"WHALE" brand Tufnol. They have also discovered that Tufnol is available in eleven other brands, each with pre-determined properties.

All brands of Tufnol are laminated plastics; each formulated to satisfy specific requirements. If your birthday falls between January 1st and December 31st this could be your lucky week—the week you discovered Tufnol.

'Phone or write to your local Tufnol Branch Office and we predict that you will thank your lucky stars.

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P3

Boiler Circulation Theory

A REPORT on an extensive series of experimental investigations of the fundamental factors influencing the circulation process in high pressure boilers was recently presented to The Institution of Mechanical Engineers, in London, by R. W. Haywood, G. A. Knights, G. E. Middleton and J R. S. Thom. The research project, the results of which are applicable also to other types of evaporative heat exchangers, was sponsored by the Water-Tube Boilermakers' Association (8 Waterloo Place, London, S.W.1.).

The primary object of the research was to establish experimental data relating to the flow conditions and pressure drop of high pressure steam-water mixtures flowing along heated and unheated pipes—in both horizontal and vertical positions. Simple boiler circulation theory is based on the assumption that the steam-water mixture moves as a homogeneous fluid, but there was little existing data on effects of relative velocity between the steam and water phases, a phenomenon which was known to exist under actual flow conditions in a boiler circuit.

In their conclusions the authors stated that, over the range of variables covered in the tests, the experimental pressure drops at 2,100 p.s.i. abs. were close to the values predicted by homogenous theory for both horizontal and vertical pipes. For horizontal pipes at the lower pressures, homogenous theory gave closer prediction of the pressure drop for heated than for unheated pipes, owing to the opposing effects of two-phase flow conditions on the frictional and acceleration pressure drops in the heated pipes.

For vertical pipes at the lower pressures, the experimental pressure drops were significantly greater than the values predicted by homogenous theory. The gravitational contribution to the total pressure drop was dominant, and it was influenced significantly by the effects of slip. Closer prediction was achieved by the introduction of the slip correction factor presented in Part 2 of the paper.

It was appreciated at the beginning of the undertaking of this research project that fundamental work such as that described in the paper was not of the kind that necessarily led to revolutionary changes in design. In this case, however, the results of the work have provided a necessary and valuable addition to knowledge of the processes occurring in the steam raising tubes of high pressure boilers. It is through the use of such information that the designer can undertake the economic proportioning of the circulating circuits of such boilers, while maintaining adequate and certain margins of safety. For that and other purposes the paper gave a wealth of information in a field in which there has been previously a scarcity of reliable data.

Photo-copying Machine Centre

TO GIVE both existing and potential users a clear unbiased view of the most suitable copying machine for their own particular business, a new company, called Conroy Copying Consultants Ltd. have opened "The Photo-Copying Machine Centre", at 33 New Cavendish Street, London, W.1.

A visit to the Centre will enable any executive to eliminate quickly from the reckoning the machines from which he could obtain little benefit, and allow him to select with confidence the machine most suited to his requirements, thus saving the time that would otherwise be spent attending individual demonstrations by many manufacturers.

Conroy's feel that the following aspects of their scheme will persuade even the most "time tied" executive to visit the Centre:

1. They specialise exclusively in copying-machines and reproduction techniques.
2. They offer the opportunity of seeing under one roof a fully comprehensive range of all processes, carefully selected from all known makes and types available today.
3. They have a staff of highly trained experienced consultants in attendance, who can offer expert advice on the use of all known makes of copying machines, entirely without obligation.
4. Not being tied to any manufacturer, they can supply the machine most suited to any individual requirement.
5. They provide a unique free-of-charge maintenance service, incorporating a guaranteed monthly visit to clean each machine supplied by them, thus eliminating the necessity for the cleaning of the machine by the user or his staff.

Although most business executives realise that a copying machine would be a valuable asset to their office administration, many have been dissuaded from advancing beyond the "vaguely interested" stage by the barrage of conflicting advantages and disadvantages each different copying machine seems to embody, and it is to these executives that Conroy's services would appear to be of special interest.

Helically-wound Waveguides

TO MEET THE GROWING DEMANDS for communication systems of large capacity a new system, using tubular waveguides, is under development by Standard Telecommunications Laboratories Ltd. For such applications special waveguides are required, and a helical waveguide is particularly attractive.

A typical helical waveguide consists of a tube, the inner surface of which is formed by an insulated helix of conducting wire embedded in a suitable medium. Immediately behind the helix there is provided a wave absorbing layer. The performance of the waveguide is governed by the diameter of the helix, the spacing of its turns, and the electrical properties of the materials used, in particular the absorbing layer. A correctly designed waveguide will favour the preferred mode of operation and suppress the parasitic ones. In this way the helical waveguide can be made to negotiate bends, and the signals can be transmitted without degradation.

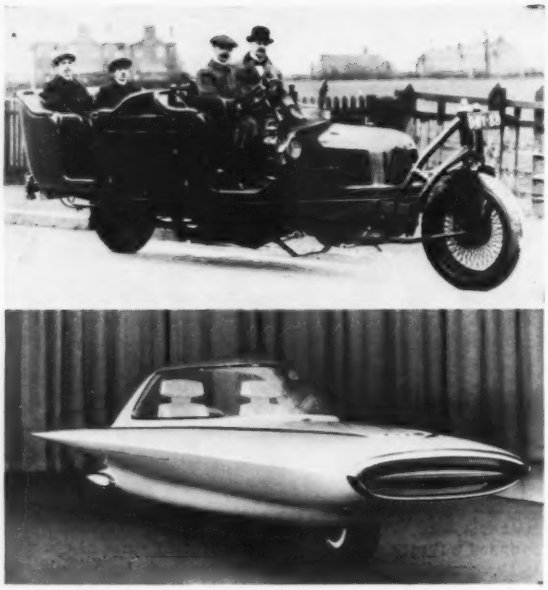
The helical waveguide is made by winding the wire forming the helix on to a cylindrical mandrel, applying the absorbing layer and then the outer case. The operation is completed by a resin impregnation process and a period of cure. Subsequently, the mandrel is withdrawn, leaving behind a length of waveguide ready for installation.

Experimental waveguides are made in 10-ft. lengths, and are assembled in the field by bonding the ends of consecutive waveguides in a suitable jig. The joints are relatively simple to make, and waveguides of many miles in length could be assembled in this way. For large scale installations, naturally, suitable automatic machines would be used.

The absorbing layer, which must have the correct resistivity, forms an important part of the waveguide. A possible and effective way of providing such a layer is by applying fibres impregnated with Aquadag (made by Achesons Colloids Ltd.) at the appropriate stage in the manufacture. Such fibres are prepared in a separate process developed by Hunting Mhoglas Ltd., of Luton, prior to the winding of the waveguide.

A helical waveguide incorporating the resistive layer, as described above, can be made in long lengths and installed under all practical conditions.

A helical waveguide during the course of manufacture. Enamelled copper wire and the fibre layer, impregnated with Aquadag colloidal graphite in water, are being wound on to a mandrel.



Two-wheeled gyrocars, old and new—(*above*) Wolseley 1912, (*below*) Ford 1961.

Progress in Transport

ONE ASPECT of the automobile that has remained largely unchanged since the days of the wagon is its basically rectangular plan form with a wheel at each corner. At the recent New York Motor Show, the Ford Motor Co. stylists advanced a two-wheel gyro-stabilised vehicle which they stated "offers countless possibilities to the imagination of the industry."

The concept of a two-wheeled vehicle is not new, the first successful prototype having been built by the Wolseley Car Co. in 1912, to the basic design of a Russian lawyer Count Schilowsky. Although various accounts of this car differ in their view as to its ultimate use, the inventor claimed that it would traverse terrain too difficult for the conventional four-wheeled vehicle.

The Wolseley gyrocar consisted basically of two wheels set in tandem, as in an ordinary bicycle, between which was slung a body containing three pairs of seats. The centre pair faced the rear, while the back seats were mounted over and slightly behind the driven rear wheel. Equilibrium was maintained by a gyroscope controlled by two pendulums (another account of the vehicle states that control was by means of a pawl and ratchet mechanism*) which brought the gyroscope into action when the vehicle leaned from the perpendicular. This gyroscope apparently accounted for approximately one-fifth to one-tenth of the total weight of the loaded vehicle, and rotated at some 1,500 r.p.m. Energy absorbed was about 1·25 h.p. When the engine was stopped, small sprag wheels on either side supported the vehicle—these were automatically lowered and retracted.

In April, 1914, the gyrocar was publicly demonstrated in Regent's Park, London. In front of a large crowd it was run up and down, stopped and started several times, and then taken for a slightly longer run.

Count Schilowsky had apparently intended to take the vehicle back to Russia, but the 1914-18 war intervened. As the gyrocar was too big for the scrap heap and was not worth dismantling it was buried in the foundations of a new building, which was destroyed in an air raid in 1940. The gyrocar was then disinterred and restored, and placed in the Wolseley Co's private museum, only to be scrapped in 1955. So came to an end a striking example of ingenuity, a concept many years before its time—even today one cannot easily foresee its future in the transport system. It is, however, worth while considering the changes that are taking place in these concepts, particularly since the advent of the Ground Effect Machines or hovercraft.

* The Editor will be pleased to hear from any reader who remembers this vehicle or its design.

The hovercraft has demonstrated its ability to travel over both land and water, but from the attention given to it by major industrial companies the emphasis appears to be on over-water travel. Before hovercraft can be used in established traffic lanes, or where accurate manoeuvrability and control is required, considerably more development is required, and it is reasonable to assume that the commercial applications will be over water or water-saturated terrain.

The most significant advantage that the hovercraft can offer is its ability to cope with the transition from water to dry land, and the increasing economy of power required as the size increases. (see *E.M. & D.*, September, 1960). The hovercraft tends to become an unwieldy vehicle in congested or built-up areas, and it is in this environment that the gyrocar or a similar development may find favour, since it requires only a narrow track at the contact point of the wheels, and in fact, air bearings similar to the Ford Levapad may be possible for use on prepared tracks.

As in all branches of engineering, each application for a particular type of transport must be considered on its own merits and in the light of its own specific requirements. A fully integrated system of transport facilities may well embrace the overhead or ground monorail (the latter employing gyro stabilisation), the conventional 4-wheeled vehicle and the hovercraft.

Selecting Materials for Isolation of Vibration

UNDER A PROJECT sponsored by the Wright Air Development Division in the U.S.A., the Stanford Research Institute has recently been investigating what mechanical properties of polymeric materials would be most useful to designers in selecting materials and specifying sizes for use in vibration isolating systems and shock absorbing mediums. This is a particularly serious problem to those concerned with protecting electronic equipment in rockets, for instance, but is also of interest in any structure where such protection must be provided.

The criterion generally used to specify the performance of such isolation devices is called "transmissibility"—this describes the amount by which a system using the device modifies force or motion. While this term is considered useful for standard products designed for a specific narrow load range, it loses its significance when used in connection with materials used in a distributed form (such as sheet, blanket, sandwich or layer) until the shape and size of the material are known. In such cases, the actual isolator must still be built and transmissibility measured under conditions approximating to those of the intended service. Not only is this expensive in terms of time and materials, but the machines for testing transmissibility are also quite costly. Because of this it is considered that the design of isolating systems using such materials in distributed form requires something more basic than "transmissibility" for describing the mechanical properties of the materials.

Undertaking research in this field, for the Wright Air Development Division of the U.S. Air Force, has been a team from the physics department of S.R.I., and their aim has been to determine whether any fundamental and readily measurable mechanical properties of a polymeric material are closely related to the transmissibility of the systems in which the material would be used. In other words, it was hoped to find properties in the isolator material that could be readily measured, and that would allow the performance of the isolator to be anticipated without actually making one and testing it.

It was found from these studies that, under certain assumed practical conditions, transmissibility can be almost precisely calculated from properties described in terms of the stress applied to the materials and the resulting strain. These quantities are technically known as the storage modulus and loss tangent of the material. The former represents the ratio of the input stress to the output strain that results directly from the stress and is in phase with it. A portion of the initial energy in the distributed type of isolator becomes heat, and is dissipated within the material itself. This aspect of strain is out of phase with the input stress, and is represented by the loss tangent.

Storage modulus and loss tangent can both be measured by a variety of methods. These quantities have been determined by many investigations, using a number of different methods over wide ranges of frequency and temperature for many polymeric materials.

SQUARE PEGS

THE shortage of skilled personnel of all types in industry gives rise to some thought as to whether the general method of recruitment and subsequent employment is in need of review. This point was raised recently in the House of Commons by both Mr. Hare, the Minister of Labour, and Mr. Lee, a Labour M.P.

In many cases today, engineering firms insist that their candidates for apprenticeship should have obtained their G.C.E. This emphasis on education is praiseworthy in that a reasonable standard among future engineers and designers is ensured, but it does not prevent a recurring void in the ranks of the craftsmen—an aspect which is emphasised in the booklet *Careers in the Scientific Instrument Industry* (published by The Scientific Instrument Manufacturers' Association of Great Britain). Many youths will not wish to remain in the workshops, but will graduate usually to the laboratory or design office where they may hope to find outlets for their ideas, and indeed they are assisted towards this goal by the various further education courses provided by their employers and the State.

Some relaxation of the initial educational standard could prove beneficial to the supply of skilled men who would be content to remain at the work bench, not through any intellectual shortcomings, but rather because of a predilection for physical rather than mental labour. For this purpose, the selection of apprentices would be better left to the experienced works foreman, because his aptitude appraisal is usually more valuable and realistic than that of the personnel officer or his staff, who more often than not have never been through the industrial mill.

To the young man who has completed a period of works training, the design office often becomes the next stage in his career, and it is in this sphere that misplacement of personnel is manifest in many quarters. The present day demand for fully qualified draughtsmen far exceeds the supply, and this situation makes it imperative that the available staff be employed to the utmost extent of their capabilities. All too often however, draughtsmen are to be found engaged on insignificant and semi-clerical jobs. This is not only wasted effort which reflects detrimentally on the administration, but is also the cause of much frustration, particularly to the young draughtsman who may feel that his lengthy studies are to prove valueless, and that his ambitions are coming to nought. Should such stupid conditions obtain for a lengthy period, the initiative and confidence even of experienced men can be undermined, with resultant inefficiency which no design organisation can afford.

Some firms are enlightened on this aspect, and recruit trainees from many walks of life for the specific purpose of completing the more menial tasks to be found in all design offices. These men are given a short training course, normally of about two months duration, before being introduced to the routine jobs awaiting them. This system, beside being economically sound, frees the qualified man to perform those duties for which he has been trained, thus helping to create that elusive contented atmosphere which does much to hold a design team together.

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TECHNICAL EXHIBITIONS CAN HELP WORLD PEACE

MANY private persons, on the technical as well as on the commercial side of industry, have stated very forcibly during the last few years that there are far too many industrial exhibitions. It is true that the cost of showing at an exhibition can be very high, and the staff concerned have a difficult and usually very tiring job in preparing the stands, arranging the exhibits and attending to enquiries, many of which do not lead directly to orders. We also have sympathy for those who merely attend the exhibitions in search of new ideas or equipment, because the bewildering number of these events requires much time and effort on the part of the visitor. We will not presume to analyse the economics of exhibitions, other than comment in passing that if so many companies continue to support them in spite of full order books, there must be some advantages; but we would like to emphasise something which has been particularly obvious at the recent British Trade Fair in Moscow—the promotion of friendly interest and understanding between the peoples of different nations.

At the Moscow Fair the British exhibitors were bombarded with questions, and many were surprised at the intelligence and knowledge of the Russian technicians. The intense interest shown by the Russian public in general was almost embarrassing, and the demand for tickets such that a flourishing black market was evident.

The warm-hearted friendliness of the Russian people was a welcome surprise to many of the British business men visiting Russia for the first time, and brought home to them the fact that they should not judge other nations by the bantering of politicians or the bickering of governments. We hope that the Russians feel the same about us—provided we are able to have free interchange of ideas on a technical level, it seems likely that they soon will, even if they do not already. A Russian engineer of some standing remarked, after a long technical discussion, that if only the technical people of our nations could get together more often the threat of war would disappear. This remark was particularly significant as it was said in front of his Director, and after a discussion which started in a cool and rather suspicious atmosphere which had suggested that they are as ignorant of our character as we are of theirs.

Another important factor which showed up during the Moscow Fair was the language barrier, which proved a far more formidable obstacle than the so-called Iron Curtain. Few English people speak Russian, and although English is the most popular second language for Russians, this has been so only in the last year or two, and as yet not many technical and business men can speak enough English for serious discussion. Conversation through interpreters is not a very satisfactory process even at its best, and when dealing with technical matters it is almost hopeless unless the interpreter is familiar with the technical jargon in both languages—a very rare and much-sought-after qualification. The British are notoriously lazy about learning foreign languages, probably because in the past they could afford to take the attitude that foreigners must learn English if they want to trade with us. Such an attitude can no longer be tolerated, and we suggest that companies who hope to do business with Russia should encourage their technical men to learn Russian.

One last point; international trade must be reciprocal, and if we are to sell our products to Russia we must also be prepared to buy from Russia. We strongly recommend our readers to visit the Soviet Exhibition at Earls Court, July 7 to 29, not only because we think they will find it interesting but also because it will be a good opportunity to see what Russia is producing for export. If the Russian Exhibition of Achievements, in Moscow, is anything to go by, the London exhibition will be a memorable event which should not be missed.

The Editor

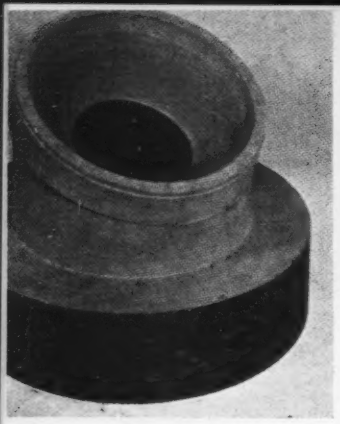

Fig. 1 (*far left*). Partially completed Astrasil nozzle seal, with fibres oriented 60° to the centre line.

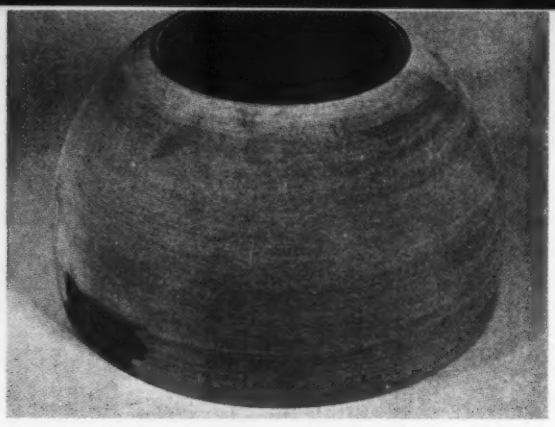

Fig. 2. Astrasil nozzle entrance liner before machining—fibre orientation 70° to the centre line.

PROGRESS WITH REFRACTORY FIBRES

In this article the author discusses some of the high-temperature insulating materials which are based on refractory fibres, including various forms of Refrasil, potassium titanate, graphite, and zirconium dioxide

by C. Z. CARROLL-PORCZYNSKI, F.T.I.

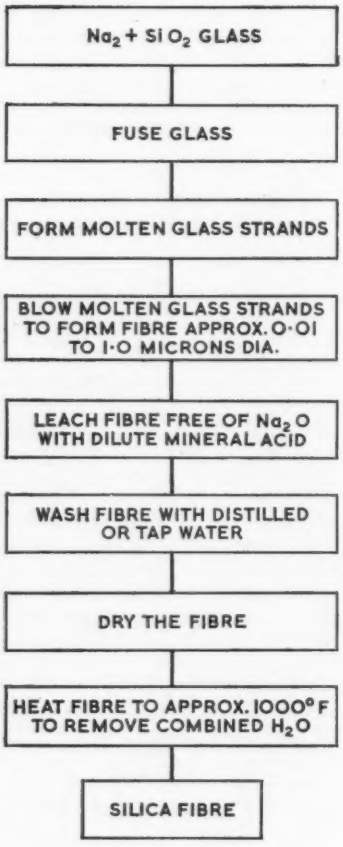
Na_2 + Si O_2 GLASS
FUSE GLASS
FORM MOLTEN GLASS STRANDS
BLOW MOLTEN GLASS STRANDS TO FORM FIBRE APPROX. 0·01 TO 1·0 MICRONS DIA.
LEACH FIBRE FREE OF Na_2O WITH DILUTE MINERAL ACID
WASH FIBRE WITH DISTILLED OR TAP WATER
DRY THE FIBRE
HEAT FIBRE TO APPROX. 1000° F TO REMOVE COMBINED H_2O
SILICA FIBRE

Fig. 3. Process for making silica fibres, according to B.P. 824,972 (L.O.F. Glass Fibre Co.).

ROCKETS and missiles, atomic reactors, jet aircraft and numerous types of military weapons all call for extremely high temperature insulating materials. At the moment, however, most efforts are being directed towards the solving of heat problems encountered in the rocket engine fields. As an example of the actual conditions encountered, the following flame temperatures and gas velocities for typical rocket propellants are listed:

	Temperature (deg. C.)	*Velocity (ft./sec.)*
White fuming HNO_3 + JP-4	2,780	5,215
Liquid O_2 + 75% ethyl alcohol	2,850	5,480
Liquid O_2 + JP-4	3,040	5,920
H_2O_2 + Hydrazine	2,320	5,430
Red fuming HNO_3 + Hydrazine	2,650	5,580

The thrust chamber of a rocket engine directly encounters one of the above temperatures, dependent upon the type of fuel used.[1]

Although refractory materials such as silicon carbide bonded with silicon nitride or refractory cements are at present providing high-temperature, shock-resistant and physically strong structures, the future in the rocket and missile field appears to belong to lighter, refractory fibre-based materials. Their lightness, combined with heat resistance, permits the increase of the payload and operational range of space vehicles and missiles.

Parallel with rocket and missile developments, research is also being intensified on ceramic, graphite, metal and inorganic polymer high-temperature-resistant fibres for other requirements, such as equipment for gas-cooled nuclear reactors, pebble heaters, tubular heat exchangers, boilers, turbines, and also for hydrodynamic studies.

The great weight and speed of modern aircraft have necessitated the development of high-temperature (430-1,095 deg. C.) friction materials, and speeds in excess of Mach 2 have created numerous new insulating problems.

The commercial success of a recently discovered method of generating electrical power from heat depends upon the development of materials suitable for handling corrosive gases at very high temperatures. This process,[2] developed by Avco Manufacturing Co., and known as magneto-hydrodynamics, involves heating a gas to a temperature of approximately 2,000 deg. C. A range of ceramic and quartz fibres has already been reviewed in previous issues of *Engineering Materials and Design*.[3, 4]

Refrasil

Numerous other refractory fibres have been recently developed and placed at the disposal of modern industry. Others are still in the pilot-plant or evaluation stages. Before discussing these new materials, mention should be made of progress in the field of one of the first and most successful refractory fibres, i.e. the leached silica fibre type, as represented by Refrasil. This type of fibre is made in the U.K. by The Chemical & Insulating Co. Ltd., of Darlington, and in the U.S.A. by H. I. Thompson Fibre Glass Co., of Los Angeles, California.

The commercial method of Refrasil production consists of leaching alkali-silicate fibres with acids (other than hydrofluoric or phosphoric acids, which attack SiO_2) to extract all the oxides other than silica. The treated fibres are then washed substantially free of acid, and may be heated at an elevated temperature to dehydrate the fibres. The finished product has approximately the following composition: SiO_2 98·5; Fe_2O_3 0·03; Al_2O_3 1·04; CaO 0·04; MgO 0·09; and B_2O_3 0·04 per cent. This process has been extensively patented by H. I. Thompson Co. and L. O. F. Glass Fibre Co., of Toledo (see Fig. 3).

The leached fibres may be dispersed in water and then flowed on to a screen to form a felt. When pressed, the fibre forms a paper which may be used for electrical or heat insulation, or as a screen for repelling the effects of radiation as in nuclear units. Refrasil is made in a variety of forms, including bulk fibre, batt, cordage, cloth, sleeving tapes and yarns. Its general properties are set out in Table 1.

Applications

In the form of blankets made from Refrasil batt covered with Refrasil cloth or with a steel gauze or stainless steel envelope, this product finds wide insulation application in the aircraft industry. In a similar form Refrasil is used to contain heat and to control the cooling process during stress relieving of welded pressure vessels, boiler drums and pipes. These blankets are of considerable value in nuclear power projects, where the welding must be carried on in "clean zone" conditions. Furnace curtains made of Refrasil cloth and cards have also found a wide acceptance.

In the nuclear reactor field Refrasil is used for both thermal and electrical applications, where its low neutron absorption eliminates trouble from radiation heating effects.

Electrical uses of Refrasil are numerous, particularly in high-temperature heating tapes, electric furnaces, thermocouple leads and laboratory equipment. Refrasil is also used as filter medium for removing dust from high-temperature gas streams, and as high-temperature packing between bricks lining a furnace.

Astrasil—Refrasil Cloth Laminates

Astrasil is the trade name of a resin-bonded laminate or moulding of Refrasil cloth impregnated with phenolic resin. Refrasil reinforced plastics have found a wide acceptance in the U.S.A., particularly in the rockets and missile

Table 1. Properties of Refrasil

Composition	Refrasil products are composed of vitreous fibres having from 96 to 99 per cent SiO_2.
Colour and appearance	All products are white in colour. Batt and bulk fibres resemble cotton. Woven products are flexible, and are similar in appearance to glass textiles.
Fibre diameter	Fibre diameters range from 0·00003 to 0·00040 in.
Thermal properties	Refrasil does not melt or vaporise until 1,650°C. At continuous temperatures above 980°C. the vitreous silica in Refrasil changes to several crystalline forms. This inversion tends to stiffen the material, but causes no change in the physical form or insulating properties. Resistance to thermal shock is very good. Refrasil can be heated to 1,095°C. and rapidly quenched in cold water without any apparent change.
Chemical properties	Similar to those of vitreous silica. The material is very stable under the action of acids and mild alkalis at both low and elevated temperatures.
Radiation effects	Because of the very low boron content of Refrasil materials, they can be used in regions of high neutron and gamma flux without appreciable radiation heating effects. The figures below were obtained by exposing Refrasil materials to neutron bombardment in the Gleep reactor at the U.K.A.E.R.E., Harwell. *Material* — *Macroscopic Nuclear Absorption Cross-section (cm.² per gm.)* Refrasil Tape T-RF-3 — 0·016 Refrasil Yarn Y-RW-445 — 0·016 Refrasil Fibre F-RF-75 — 0·019 The low values mean that Refrasil materials are completely satisfactory for reactor use, especially since the thermal properties of Refrasil remain substantially unaffected by deuteron bombardment.
Electrical properties	Refrasil materials are extremely good high-temperature electrical insulants, and are in fact the only real flexible materials available in textile form that will serve as electrical insulants at temperatures up to 1000°C. The table below shows values for the insulation resistance of Refrasil cloth (C-RF-M and C-RF-H) at various temperatures, as determined by the National Physical Laboratory. *Sample* — *Temperature (°C.)* — *Insulation Resistance (ohms/cm.²)* C-RF-M — Room temperature 20 — 5×10^7 200 — 5×10^{13} 500 — 2×10^9 900 — 2×10^7 C-RF-H — Room temperature 20 — 5×10^9 200 — 2×10^{13} 500 — 5×10^9 900 — 5×10^7

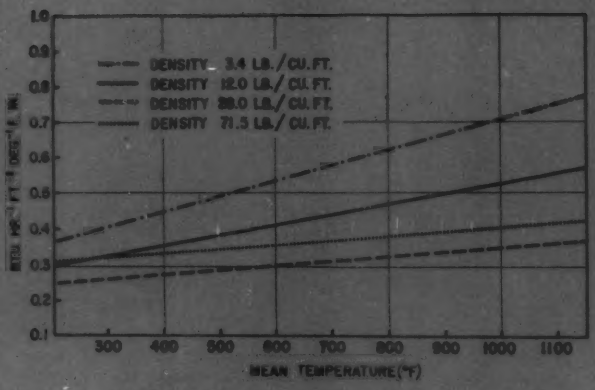

Fig. 4. Thermal conductivity of Tipersul fibrous potassium titanate, at various densities.

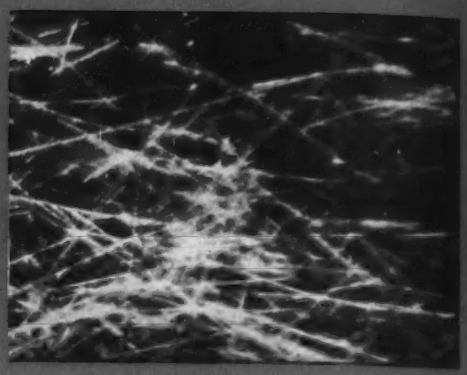

Fig. 5. Enlarged view of Tipersul fibres.

Fig. 6. Showing how the heat from a 3,320 deg. C. oxy-acetylene torch melts a ¼-in copper plate without penetrating the potassium titanate fibre block behind it.

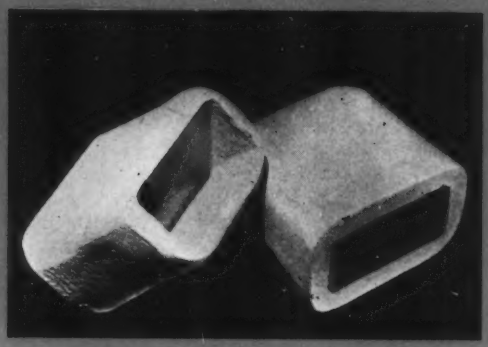

Fig. 7. Uniform rectangular pipe shapes formed from Resistotherm insulating material. Note that the shapes are uncemented and free of seams.

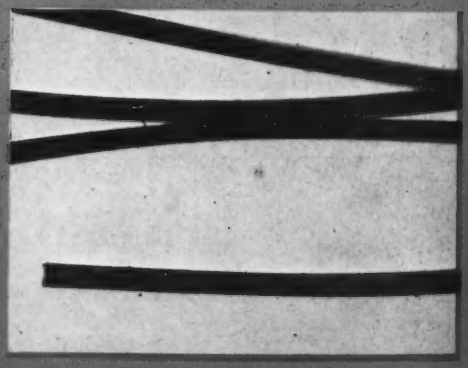

Fig. 8 (above). Graphite fibres. (×400.)

Fig. 9 (*left*). All graphite—and a yard wide! Here an experimental air foil section is being prepared for tests on fabricating techniques for reinforced plastics, and subsequent analysis of properties at high temperatures.

Table 2. Properties of Astrasil at 21°C.

Flexural strength (p.s.i.)	25,000
Tensile strength (p.s.i.)	19,000
Young's modulus (p.s.i.)	$2{\cdot}5 \times 10^6$
Specific gravity	1·4
Water absorption	3%
Dielectric strength (volts/mil. at 50 c/s in air)	60
Volume resistivity	$8{\cdot}0 \times 10^{11}$
Power factor at 9·4 × 10 Mc/sec.	0·012 to 0·025
Dielectric constant at 9·4 × 10 Mc/sec.	4·18
Resin content	33%

The following data are based on direct oxyacetylene flame impingement on ¼ in. thick specimens. The temperature of the flame was 2,480°C.

Material	Burn-through time
Astrasil	25 min. 35 sec.
Glass fibre/phenolic resin	2 min. 12 sec.
Mild steel	5 min. 26 sec.
Stainless steel	9 min. 8 sec.

Quoted from the Astrasil technical data sheet of The Chemical & Insulating Co.

Table 3. Properties of Tipersul fibre

Average dia. (microns)	1
Length after dispersion (mm.)	0·2 to 0·5
Melting point (°C).	1,370
Surface area (sq. m./gm.)	11
Theoretical density (gm./cc. or lb./cu. ft.)	3·6 225
Calculated specific heat (B.t.u./°F./lb.)	0·22
Hardness (mohs)	4·0
Moisture pick-up (%)	
47% r.h.	0·34
90% r.h.	1·7
Tensile strength (p.s.i.)	24,000
Elongation at break (%)	0·59
Modulus in tension (p.s.i.)	4×10^6
Chemical composition (approx.)	$K_2Ti_6O_{13}$
Infra-red reflectance	High
Thermal conductivity	Extremely low
Heat stability good at:	1,095°C
useful to:	1,205°C
Vibration resistance	Good
Sound absorption	Good
Electrical properties	Fairly good
Formability	Good
Compressive strength (high density)	Good

fields. They are now also available in the U.K., due to co-operation between fibre producers (The Chemical & Insulating Co.) and Microcell Ltd.

Potassium Titanate Fibres—Tipersul

Du Pont Co.'s fundamental research on new forms of inorganic materials has led to the synthesis of fibrous potassium titanate, which has been found to have desirable properties for many high-temperature applications.

The potassium titanate fibres as prepared have an average diameter of about 1 micron, and their length ranges from 1 to several mm. It has been reported, however, that under the most favourable conditions fibres 2 to 3 cm. in length have been produced.[17] The fibres have a surface area of 11 sq. m./gm., which is high for their size. This, and other factors, suggest that the fibres are laminates built up of crystals of much smaller dimensions, probably a number of parallel fibrils having a diameter of 0·1 micron or less.

The fibres, though crystalline, are fairly flexible, and melt quickly at 1,370 deg. C. to give a non-viscous liquid. After continuous heating at 985 deg. C., a change in crystalline structure occurs. This change does not destroy the fibrous nature of the material.

The chemical stability of Tipersul is good—it is unaffected at room temperature by concentrated hydrochloric, sulphuric and nitric acids. However, it shows slight but definite signs of attack on exposure for one week to boiling 5 per cent HCL and 5 per cent NaOH.

The thermal insulation properties of Tipersul are excellent (see Fig. 4), and are attributed to the fact that compacts of the fibres scatter infra-red radiation to a high degree. Table 4 shows the effectiveness of Tipersul as a furnace insulation. During the initial stages of evaluation, a test muffle furnace was insulated with potassium titanate fibres and operated both continuously and in cyclic fashion for over a year at temperatures up to 1,095 deg. C. No shrinkage of the insulation was observed. Power input to maintain a given temperature remained constant over the test period.

In another comparative test, a section of a 30 in. dia. cylindrical reactor was insulated with a 2 in. thickness of fibrous potassium titanate block. The standard insulation for a similar reactor was a 2 in. thickness of aluminium silicate fibre felt having a density of 12 lb./cu. ft., backed by a 6 in. thick fibre block reinforced with diatomaceous earth. This gave a total of 8 in. of insulation for the standard reactor. Both reactors were operated at an inside temperature of 980 deg. C., under constant conditions. The average surface temperature for the reactor insulated with a 2 in. thickness of fibrous potassium titanate was 78 deg. C., the average surface temperature of the standard reactor insulated with an 8 in. thickness of conventional insulation was 86 deg. C.

Fabrication

Potassium titanate fibres as produced are in the form of irregular masses of fibres or lumps. The fibres can be exfoliated from the lumps by using a stirrer that gives high liquid shear. This gives a water dispersible pulp which can be handled in much the same manner as paper pulp to form papers, felts, mats or blocks by felting on a screen using pressure or vacuum filtration. Blocks and felts formed in this manner have adequate strength for most uses without the use of binders. Curved or unusual shapes can be formed from the wet mats, which hold their contoured shape when dried. Blocks or felts of the fibres show exceptional dimensional stability after prolonged heating—after six days ageing at 1,040 deg. C., blocks of the fibres show no dimensional change. The thermal conductivity of mats made from the fibres is slightly decreased by prolonged heating at 1,040 deg. C. Blocks of the fibres can be exposed to temperatures up to 1,205 deg. C. for extended use without undue damage to the material. Pad strength is increased by extended heating at 980-1,095 deg. C., as shown in Table 5.

For many uses, improvement in the properties of fibrous potassium titanate pads, felts, papers and formed shapes can be made by the use of both inorganic and organic binders. Colloidal SiO_2, Al_2O_3, TiO_2 and colloidal clays are

Table 4. Comparative results of tests on fibrous potassium titanate as a furnace insulation

Insulation	*Standard Muffle* 1,430°C. firebrick	*Special Muffle* Fibrous potassium titanate block
Thickness	3 in.	0·94 in.
Density of insulation	48 lb./cu. ft.	17·2 lb./cu. ft.
Weight of furnace	66·2 lb.	17·7 lb.
Hot chamber volume	230 cu. in.	222 cu. in.
Overall size	3,175 cu. in.	1,160 cu. in.
Heat-up time, 21 to 1,000°C.	150 min.	25 min.
Power consumption to maintain 1,040°C.	1,150 watts	580 watts
Furnace case temperature when inside temperature is 1,050°C.	160°C.	127°C.

Fig. 10. The refractory properties of graphite cloth are well illustrated in this test, in which an oxy-acetylene flame is passed over a strip of stainless steel mesh (*left*) and on to a band of graphite cloth of square weave, 28 × 28 construction. With the flame set low on oxygen, so as not to oxidise the graphite, the heat quickly melts the steel mesh, but the graphite cloth merely glows, since it does not melt at ordinary pressures.

effective binders for pads of the fibres where improved strength is needed. Where flexibility is required in the titanate felts and papers, high-temperature polymers and elastomers are used.

A castable material was obtained by mixing 1 lb. of titanate fibres with 1·7 lb. of Ludox AS (colloidal silica) plus 0·58 lb. of Victamide (ammonium polyamide phosphate) dissolved in 0·42 lb. of water. After dissolving the Victamide in water the pH was adjusted to 6 by the addition of a small amount of ammonium hydroxide. This solution was mixed with the Ludox AS. The fibres were worked into the mix, then cast into a form and dried at 150 deg. C. The resulting product was a rigid structure which had a compressive strength of approximately 500 p.s.i.

Table 5. Properties of Resistotherm plastics materials

	No. 1111	*No. 1114*	*No. 1211*
Specific gravity	1·7	1·7	1·6
Maximum tensile strength (p.s.i.)	6,000	6,000	—
Flexural strength at 260°C. (p.s.i.)	6,500	6,500	15,000
Impact strength (Izod notch: ft./lb./in.)	0·48	0·48	—
Compressive strength (1,000 p.s.i.)	11	11	—
Operating temperature (°C.)	260	315	260
Co-efficient of expansion (10^5 in./in./°F.)	1·8	1·8	—
Rigidity	Rigid	Rigid	Rigid

Nos.1111—High-temperature phenolic with potassium titanate and 1114 and asbestos as fillers.
No. 1211—Epoxy binder with potassium titanate and asbestos as fillers.

For some applications an erosion-resistant surface is needed on formed articles of the fibres. This can be accomplished either by melting the surface of the pad or block, which gives a ceramic-like coating, or by painting the pads with a high-temperature silicone-base aluminium paint and then firing at 650 deg. C. to fuse the aluminium flakes and obtain a continuous adherent coating.

Some thermal insulation uses for this material have already been described. It has been reported that Tipersul has also been successfully used as an additive in various insulation systems, and in the form of compressed sheets as flange gaskets at 800 deg. C. and 100 p.s.i.

It has been reported that Tipersul has also been successfully used as an additive in various insulation systems, and in the form of compressed sheets as flange gaskets at 800 deg. C. and 100 p.s.i.

In view of the fact that Tipersul fibre is inert to dilute acids, alkalis, salt solutions and organic solvents, and has very high porosity and good resistance to mechanical compression, it is being evaluated in various filtration applications. Another promising field for this material is electrical insulation at high temperatures.

Several other uses are under consideration, such as fibrous pigment for paints and paper, acoustical insulation, catalyst support and filler for insulating panels. Uses in protective clothing, where the soft talc-like feel of the compacts may be of great value, are being studied.

Strength improvement advantages have been demonstrated for the titanate fibres over conventional reinforcing agents for some moulding compositions. Epoxide resin mouldings reinforced with titanate fibres at high fibre loading showed better compressive strength; however, higher moulding pressures were required. The titanate fibres, due to their high reflectance of infrar-red radiation, should give longer life to ablative type moulded compositions which are exposed to very high temperatures.

Resisto Chemical Inc., of Wilmington, Del., U.S.A., recently announced the successful production of complex integral shapes called Resistotherm, based on potassium titanate fibres. These materials are characterised by low density and very low thermal conductivity at 1,095 deg. C. The wide variety of specially formed Resistotherm shapes that this Wilmington firm is now prepared to supply to order includes rectangular and curved pads[19] (see Fig. 7).

Graphite Fibres

Commercial graphite is a polycrystalline refractory material prepared by mixing a filler material (usually calcined petroleum coke) with a binder (usually coal-tar-pitch). Mixture is formed to the desired shape by moulding or extrusion, and baked in an inert atmosphere. It is then heated to 1,930-3,040 deg. C. to promote crystal growth.[20]

Union Carbide International Co. have recently developed a manufactured graphite in the form of flexible fibres and fabrics. The process, for which patents have been applied, consists essentially of graphitising a fibre or fabric, such as rayon, by heating it electrically to a temperature approaching 2,980 deg. C. The general properties of manufactured graphite and graphite textiles are shown in Table 6 and illustrated in Figs. 8-10.

Several methods of graphite fibre production are covered by US Patents 2,796,331, 2,822,321 and 2,963,739.

Graphite Fibre-reinforced Plastics

Due to their excellent resistance to high temperatures, graphite textiles have already been successfully used in the rocket and missile fields. Rocket nozzles and other solid propellant rocket motor parts reach temperatures of 2,760 deg. C. and higher, while, upon re-entry, missile nose cones may be subjected for short periods to 6,670 deg. C. or greater.

Table 6. Properties of manufactured graphite (Courtesy: Union Carbide International Co., U.S.A.)

Melting point	Does not melt at atmospheric pressure.
Sublimation temperature	Approximately 3,600°C.
Tensile strength	Varies with grade, but has the unusual feature of increasing with temperature, the strength at 2,500°C. being approximately twice that at room temperature.
Chemical resistance	Resistant to practically all acids, alkalis and organic compounds except those of a highly oxidising character, and is unreactive with many metals (e.g., zinc, aluminium, manganese, copper and copper alloys) and metal producing slags at their melting points.
Thermal expansion	Coefficient of thermal expansion at room temperature is approximately 1 to 4 × 10^{-6}/°C. Mean c.t.e. from room temperature to 3,000°C. is approximately 4 to 7 × 10^{-6}/°C.
Thermal conductivity	0·3 cal./cm. sec. °K. at room temperature. Approximately one fifth of this value at 2,200-3,000°C.
Nuclear properties	Good neutron moderator—low neutron capture cross-section.
Fibres and Fabrics Tensile strength	The room temperature tensile strength of graphite textiles varies with the type of fibre and fabric. Certain experimental graphite yarns have shown tensile strengths as high as 15,000 p.s.i., or over one gm./denier.
Bulk density	The bulk density of graphite fabrics is obviously related to the fibre and type of weave of the fabric. The real density of the fibre itself is comparable to that of manufactured graphite, but the bulk density of textile forms is much less, varying from around 20 lb./cu. ft. for some fabrics to less than 1 lb./cu. ft. for certain types of batting.
Chemical analysis	Most graphite textiles have less than 0·1% ash. For special purposes, it appears feasible to produce graphite textile forms of spectroscopic purity, that is with no determinable ash.

Zirconium and other Metal Fibres

A recent innovation is refractory fibres produced from metallic oxides. It has been reported[24] that heat-resistant high-strength fibres can be made from metallic oxides by a relatively simple process developed by Horizons Incorporated Co., of Cleveland. Typical is aluminium oxide fibre having a tensile strength of 300,000-400,000 p.s.i.

It has also been found that polycrystalline molybdenum fibres[24] can be produced from molybdenum wire at elevated temperatures in an electric field of 4,000V.

Following favourable preliminary appraisal and test results, Minerals & Chemicals Phillip Corp. have initiated work on the design and erection of pilot plant for the manufacture of fibres from zirconium dioxide. These new fibres are being developed principally for ablation-type applications. The approximate properties of these refractory fibres are shown in Table 7.

Besides metallic oxide fibres, considerable progress has been made in the field of sintered metal fibre articles.[25]

Metallised glass fibres are another promising development which should provide an answer to various high-temperature insulating and structural problems. Great activities in this field are evidenced by numerous patents taken out recently both in Europe and in the U.S.A.[25–32]

Table 7. Properties of zirconium dioxide fibres

Chemical composition	Essentially ZrO_2 plus 5% CaO to stabilise the cubic ZrO_2 structure.
Fibre character	Polycrystalline.
Fibre length	Short to medium staple (up to ½ in.).
Specific gravity	5·9.
Melting point	Approx. 2,600°C.
Resistance to continuous exposure	Withstand heats in excess of 1,650°C. for prolonged periods.
Availability	Fibres and paper.

Fig. 11. Zirconium fibres (×400). These are being used for phenolic laminates in the investigation of structural composites, thermal insulation and ablation shields.[33]

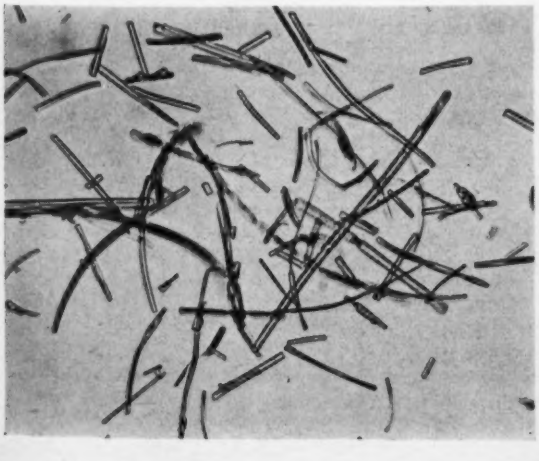

Fig. 12. A 10-ply laminate of Pluton heat-resistant fibre, reinforced with a high-temperature phenolic resin, withstands 2,670 deg. C. without burning the operator's fingers 3 in. from the "hot spot".

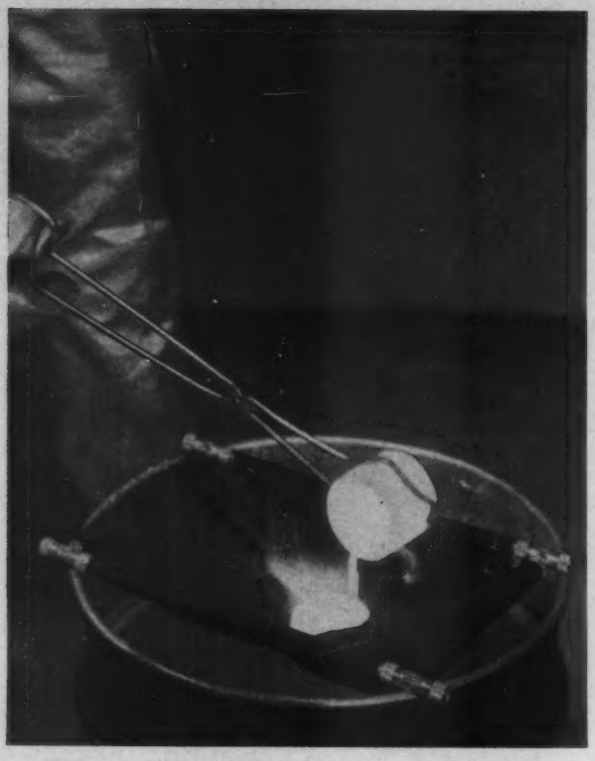

Fig. 13. A 1-lb slug of molten steel, heated to 1,650 deg. C., is poured on to a 1 lb./sq. yd. Pluton fabric.

Fig. 14. After cooling, the solidified slug of steel is lifted off the fabric, which has not been charred or melted by the molten steel.

Pluton

While reviewing recent progress in the refractory fibre field, mention should be made of a new and *organic* fabric called Pluton, developed by the Minnesota Mining & Manufacturing Co. It is claimed that this fabric is, besides its phenomenal heat resistance, electrically non-conductive, and that it has low thermal conductivity (see Figs. 12-14) and is free from elemental carbon.

So far, details of the method of its manufacture and its chemical composition are not available, but the makers state that the fibres are composed of molecules containing carbon, hydrogen and oxygen.

Table 8. Properties of Pluton

Specific gravity	1·45
Tenacity	0·8 gm./denier
Electrical resistance	greater than 100 megohms after 10 min. at 705°C.
Thermal conductivity	0·42 B.t.u./hr./sq. ft./°F./in.
Chemical resistance after 100 hr. exposure at R.T. to:	
85% phosphoric acid ...	negligible loss in strength
hydrochloric acid	15% loss in strength
sulphuric acid	25% " " "
Heat resistance	does not melt up to 10,000°C.

Pluton can be used for high-temperature reinforced plastics, insulation, anti-arc wraps for electrical power plants, fire protective curtains, etc. It is reported that Pluton-phenolic resin laminate is now being evaluated for nose cones and rocket engine parts (see *Asbestos Bulletin*, No. 1, p. 30, February 1961).

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GAS-LUBRICATED BEARINGS

THE use of bearings which are lubricated by gas in the same way as they are usually lubricated by oil is a very recent development for practical industrial machines. The idea however, was first considered at least as early as 1854. In 1897 "an air-lubricated journal" was described by Kingsbury, and a beautifully simple demonstration of an air-lubricated thrust bearing was made by the famous Lord Rayleigh in 1918, using polished and etched pennies.

The design of pumps to circulate the hot gas for a gas-cooled reactor presents a problem which cannot be solved with complete satisfaction if oil-lubricated bearings are to be used. There are two particular difficulties. The greater one is that there must be no risk of oil entering the gas circuit; if it were to do so it would be irradiated, and might interfere with the operation of the reactor. Further, any rotating shaft passing through the wall of the gas circuit must be sealed very effectively against leakage of the gas. Shaft sealing is a complexity which it is desirable to avoid.

If gas-lubricated bearings are used, instead of oil-lubricated, the problem may be solved by putting the motor and the bearings within the gas system, the bearings then being lubricated by the gas, and no rotating shaft having to pass through the wall of the pressure system.

The advantages which make this design attractive in nuclear engineering apply also to other gas circuits, so gas-lubricated bearings should soon be making their appearance in various other types of industrial plant. The advantages may be summarised as follows:

1. Gas bearings not only require no external services for the supply of lubricant, but need virtually no maintenance and can be run continuously for years without attention.
2. The power losses in gas bearings are very much smaller than those in oil-lubricated bearings.
3. As gases become hotter, they become more suitable as lubricants, generally with no upper temperature limit, whereas oils become less effective as they get hotter, and break down chemically at a temperature which is inconveniently low in many applications.
4. The maximum speed of operation of oil-lubricated bearings is restricted by the generation of excessive heat. Gas bearings do not suffer from this restriction and can be run at extremely high speeds.

Plain bearings, whether the lubricating field is oil or gas, may be grouped according to whether the pressure which supports the load is generated externally or within the bearing by its own rotation. Bearings of the latter type are called hydrodynamic. Both types were included in a recent research programme at D. Napier & Son Ltd., but for simplicity this article refers to the hydrodynamic type only.

Fig. 1 shows the very small clearance (0·0005 in.) between sleeve and shaft, the relevant diagram being magnified for the purpose. The faster the shaft turns, the greater the pressure in the film of air which is dragged between the members, and the nearer the shaft is forced towards the centre of the bearing. If it is running too near the centre, however, it is likely to whirl in an unstable way and cause damage. The greater the load, the nearer the shaft is pushed towards contact with the sleeve. While starting and stopping, therefore, the shaft turns in contact with the sleeve during the time that the speed is too low to generate the pressure necessary to separate the members. The main criteria of the performance of a bearing of this type are thus concerned with load, speed and rate of wear during starting and stopping.

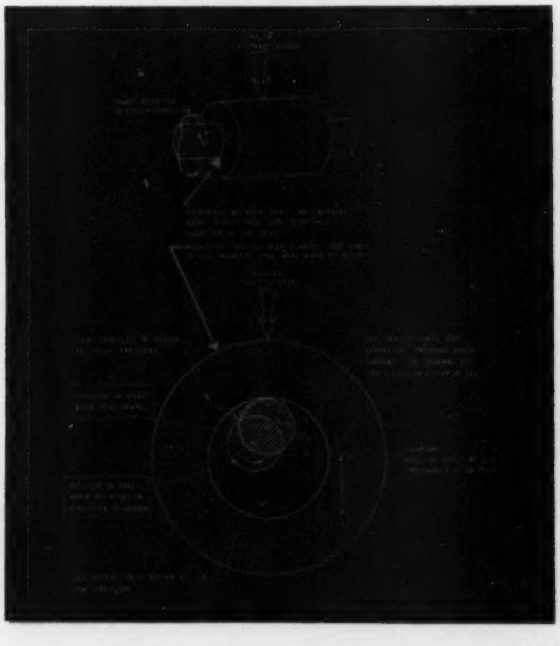
This method of operation would apply equally well to a hydrodynamic journal bearing lubricated with oil. The actual values calculable from the oil-lubricated bearing theory do not apply to gas bearings, however, because while oil is not significantly compressible, except at very high pressures, gases are easily compressible. The properties of the lubricating gas are therefore different at different points around the bearing, so that a new theoretical basis is required for calculating the exact position the journal will take up at any particular set of conditions.

A further result of the same effect is that the lubricating gas has different properties when the bearing is within a gas circuit under pressure from those when it is operating at atmospheric pressure. The effect of operation in a compressed gas is to increase the load capacity of the bearing considerably. A bearing 4 in. long on a shaft of 2 in. dia. might support 80 lb. when running in the free atmosphere, but 200 lb. when running in air at a pressure of 250 p.s.i.

The materials selected for the two parts of a bearing must obviously be able to withstand prolonged operation in the working environment. They must also be resistant to wear when rubbing together during starting and stopping, and must expand and contract together as temperature changes, without seriously altering the dimensions of the clearance on which the operation of the bearing depends.

Research work is continuing on the development of bearings capable of still higher loads, and on the solution of the various problems which appear as gas bearings are applied to special industrial projects.

Fig. 1. Diagram illustrating the principle of the hydrodynamic journal gas-lubricated bearing.



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PROBLEMS IN DESIGN

Problem No. 17 (March): Two shafts in the same plane, e.g. camshaft and crankshaft, are coupled by chain, gears, or other means to provide a fully reversible drive.

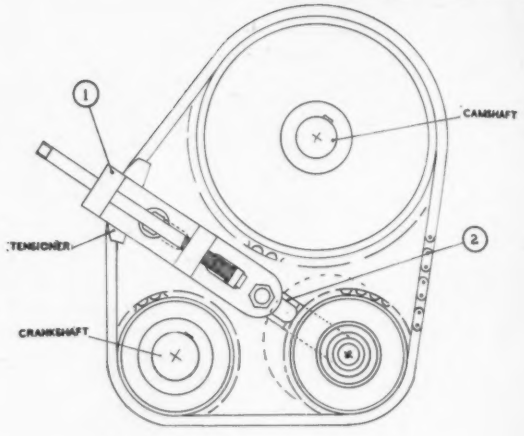
It is desired to alter the phasing of the camshaft and crankshaft by $\pm 5°$ (a total of 10° movement) while the shafts are in motion. Assume the drive transmitted to be approximately 4 b.h.p., and the maximum speed of the drive shaft to be 4,000 r.p.m.

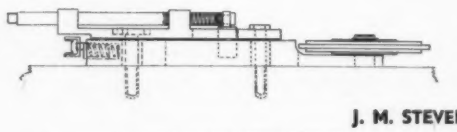
Only a few of the large number of entries received for the above problem could, in our view, be seriously considered by a manufacturer of internal combustion engines as possible solutions to the problem of how to alter the phase relationship of a crank to its camshaft. As the problem of phase relationship frequently arises in other kinds of machinery, however, we have decided to include in our selection several solutions which, although obviously rather impractical for varying the timing of a camshaft, might well be useful in other applications.

The various types of solution submitted can be divided into four main kinds. The first of these involves the use of a chain drive having two idler sprockets, or one idler sprocket and a friction pad. The idler sprocket assembly is either moved in a straight line across the plane of symmetry of the drive, as in the entries of **J. M. Stevenson** and **C. D. Waters**, or in an arcuate path about one sprocket centre. Similar schemes came from a number of other readers. The trouble with this kind of solution is that a spring must be incorporated, since the tension in the chain on each side does not bear a linear relationship to the movement of the sprockets, or sprocket and pad. Such an arrangement could not be considered satisfactory for a two-way drive, as in one direction of rotation the driving side would be operating against a spring which might give rise to an independent source of phase change, particularly when the engine was being throttled. To make a workable scheme without any kind of spring tensioner, using a chain drive and moving idler sprocket assembly, would necessitate the rather ungainly idea of using no less than four extra idler sprockets (see inserted sketch). This would certainly be ruled out, however, for an engine application.

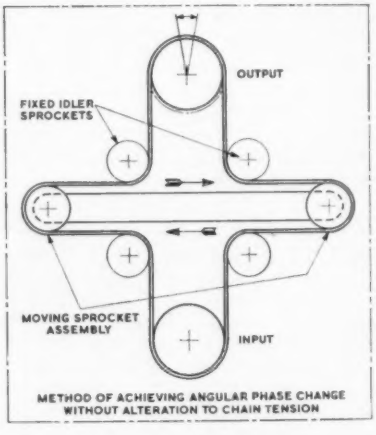
The second type of entry relies on the principle that, in an epicyclic gear train, by moving the outer toothed ring it is possible to alter the phase relationship of the planetary gears to the sun wheel. In some versions the same effect is achieved by moving the planetary gears. **A. W. Bews** chose the former method, while **R. J. Morrison** chose the latter. A rather more elaborate entry by **G. G. Lucas** also comprises a scheme for effecting the reversal of the engine rotation, while retaining the same direction of rotation for the camshaft as before. This provision is made in order that one set of asymmetrical cam profiles can be used. The camshaft is driven through a 4:1 epicyclic reduction gearbox, consisting of a gear *A* fixed to the engine crankshaft, driving through the planet assembly *B* and *C* to the fixed annulus gear *D*. Drive to the camshaft is taken via *E*. When the direction of rotation of the camshaft is changed, the camshaft drive is taken from the rotating annulus gear *F*. The fixed gear *D* can be moved round in either direction by a manually operated worm *H*. Other entries in this category were received from **G. G. Riley**, **M. Humphreys** and **C. H. Watson**, and a hydraulically operated one from **J. E. Gilliam.**

The need to provide for small angular changes in phase between two inter-connected shafts is perhaps not as

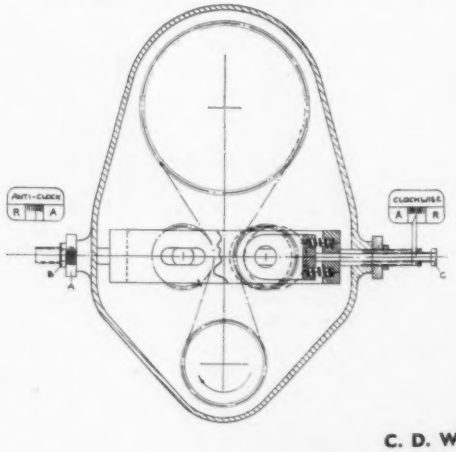




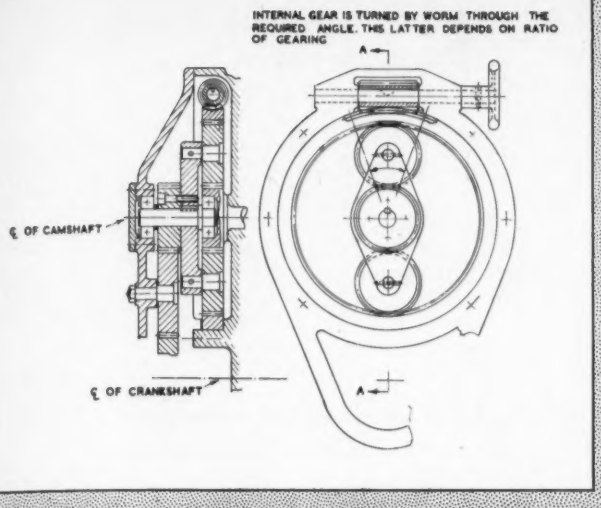
J. M. STEVENSON

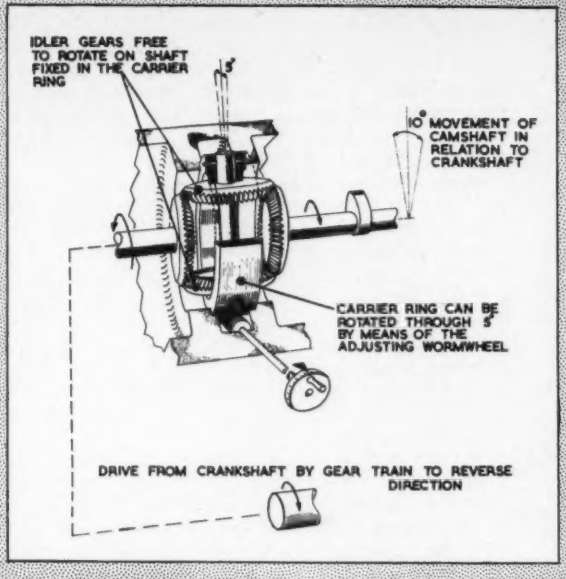


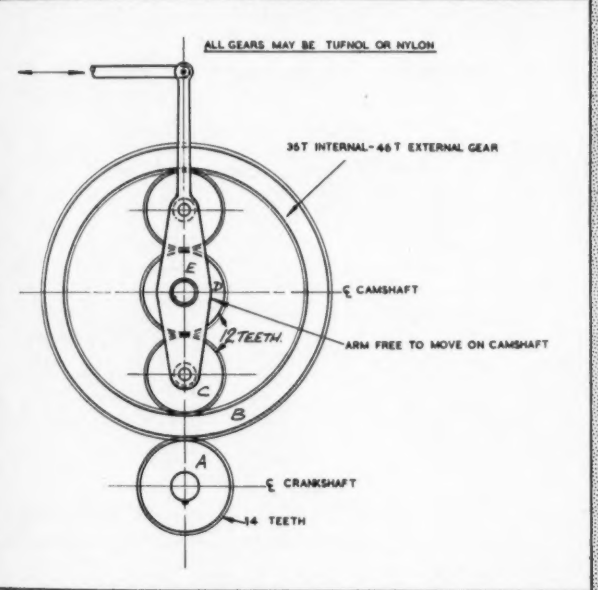
METHOD OF ACHIEVING ANGULAR PHASE CHANGE WITHOUT ALTERATION TO CHAIN TENSION

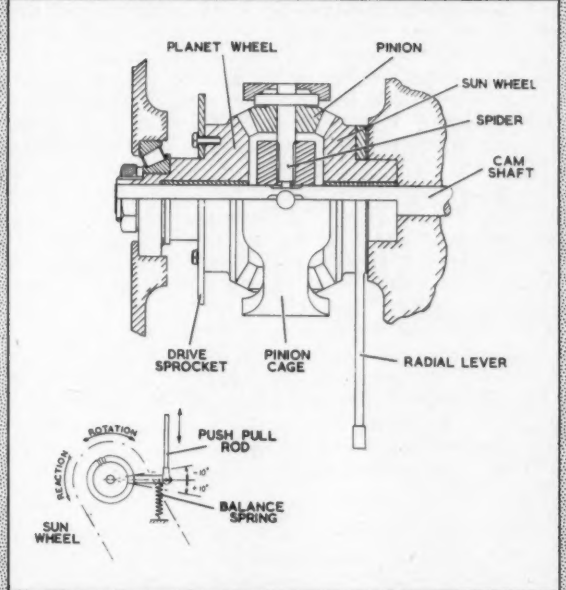


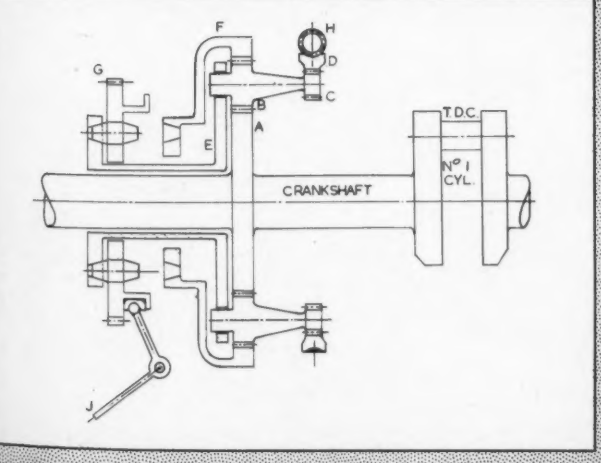
C. D. WATERS


INTERNAL GEAR IS TURNED BY WORM THROUGH THE REQUIRED ANGLE. THIS LATTER DEPENDS ON RATIO OF GEARING
A
℄ OF CAMSHAFT
℄ OF CRANKSHAFT
A


IDLER GEARS FREE TO ROTATE ON SHAFT FIXED IN THE CARRIER RING
5°
10° MOVEMENT OF CAMSHAFT IN RELATION TO CRANKSHAFT
CARRIER RING CAN BE ROTATED THROUGH 5° BY MEANS OF THE ADJUSTING WORMWHEEL
DRIVE FROM CRANKSHAFT BY GEAR TRAIN TO REVERSE DIRECTION







O.W.BEWS

K.P.KING

R.J.MORRISON

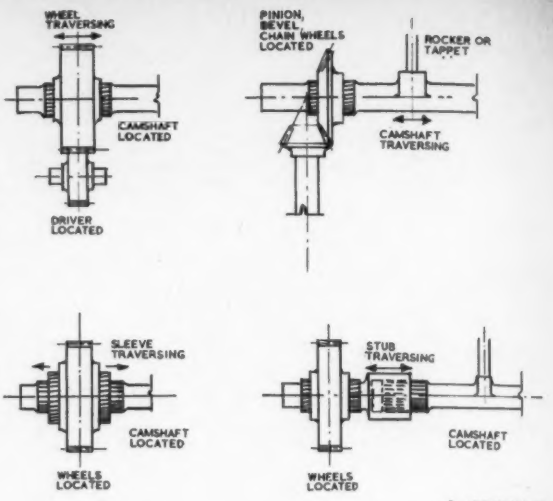
J.FISHER

G.G.LUCAS

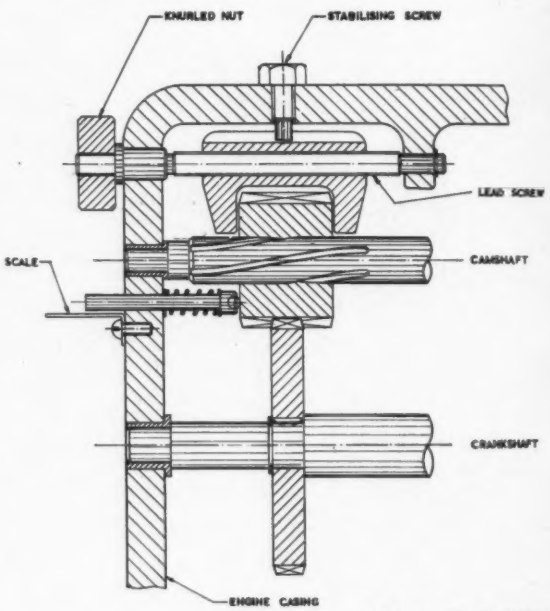
common as the need for a means of varying the phase continuously. For this purpose the planetary gear can be used, but so also can the type of entry submitted by **K. P. King** and **J. Fisher.** These employ a differential gear. In Mr. King's entry, the normal drive between the crankshaft and camshaft is replaced by a system of gears arranged to rotate the input shaft of the camshaft advance-retard unit in the reverse direction to the crankshaft. As the drive is reversed when passing through the unit, the camshaft and crankshaft rotate in the same direction. The unit consists of two idler wheels, free to counter-rotate on a common shaft. This shaft is diametrically fixed in a carrier ring which can be rotated a limited amount by adjusting the worm wheel. To alter the phasing of the camshaft by $\pm 5°$, the carrier ring needs to be rotated by $\pm 2\frac{1}{2}°$. Mr. Fisher's entry employs much the same principle. Both could be made to give much wider or even continuous phase changes. A similar idea came also from **D. G. Clayton.** We consider this idea to be unnecessarily elaborate for the application.

We now come to the third and last type of entry. Among those received are several which could be considered as the basis for a practical and simple system eminently suitable for the engine application. All of these depend on either using the movement of a helical gear along a straight spline or keyway, which we consider the better way, or alternatively moving a spur gear along a helical spline or keyway. This cannot, of course, be done with an intermediate single helical gear, as no phase change would result. One reader fell into this booby trap. He shall be nameless. **J. Croome** shows four sketches of the essential ways of attacking the problem. Good entries in this category came from **H. R. Horton**, **E. Clayton**, **P. T. C. Wilkinson**, **J. F. Richardson** and **D. Biggs**, and a better one from **W. S. Spofforth**. We prefer Mr. Spofforth's type of entry as it uses a straight spline and a helical gear. **A. P. Gonda**, of Tel-Aviv, uses a single helical keyway cut in the bore of the stationary camshaft gear, and a rack-operated bar and finger to effect phase change. **P. T. C. Wilkinson** employs a screw-operated stirrup to move a straight spur gear along a spirally cut spline. So, also, did **A. J. Clark**.

Best of all we consider to be the entry from the **Vavell Syndicate**, which uses the axial displacement of a 45° double helical gear to produce the necessary 5° rotation of the camshaft required. The cunning in this arrangement is that no spline or keyway is necessary, there is no axial component in either direction on the double intermediate gear, and the axial movement required to bring about the phase change is small.



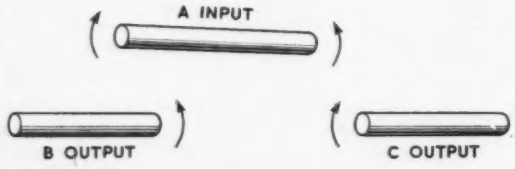
J. CROOME



P. T. C. WILKINSON

PROBLEM IN DESIGN No. 21

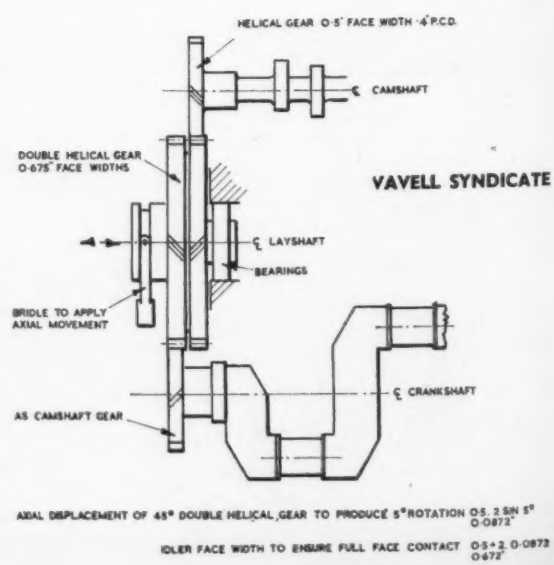
Here is this month's problem



Devise a mechanism which, with three shafts arranged as in the sketch, will bring about the following:

When shaft *A* revolves clockwise, shaft *B* revolves counter-clockwise and shaft *C* remains stationary. When shaft *A* revolves counter-clockwise, shaft *C* revolves clockwise and shaft *B* remains stationary.

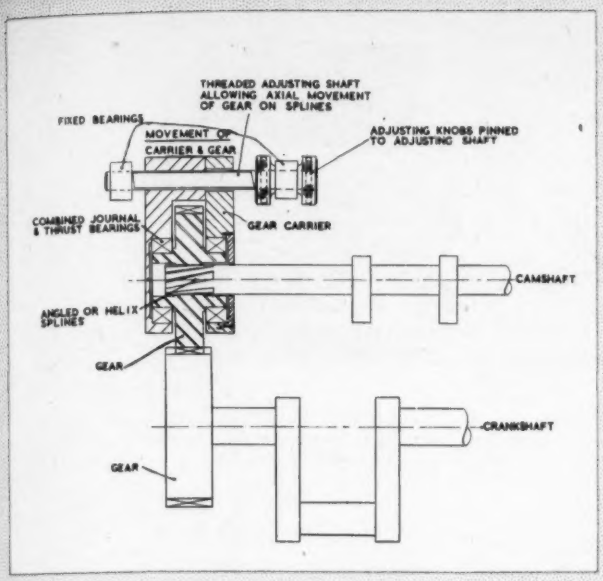
Best solutions to "Problems in Design" are published and paid for. Send your solution for this month, with a drawing or diagram (in Indian ink and not more than 12 × 12 in., please!), to the Editor, "Problems in Design No.21 (July)". Closing date August 20.

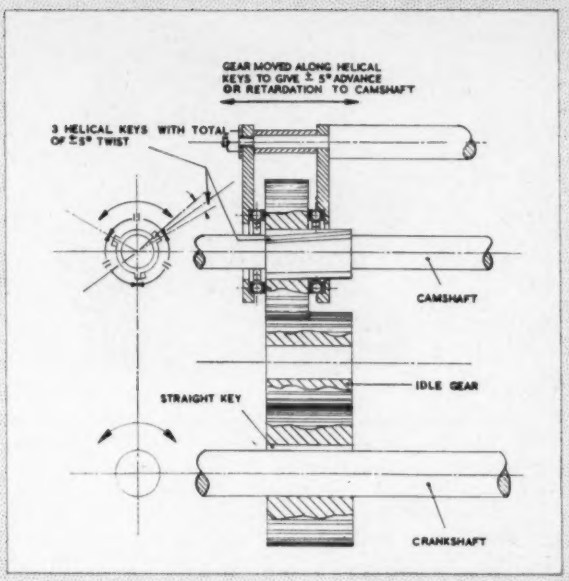


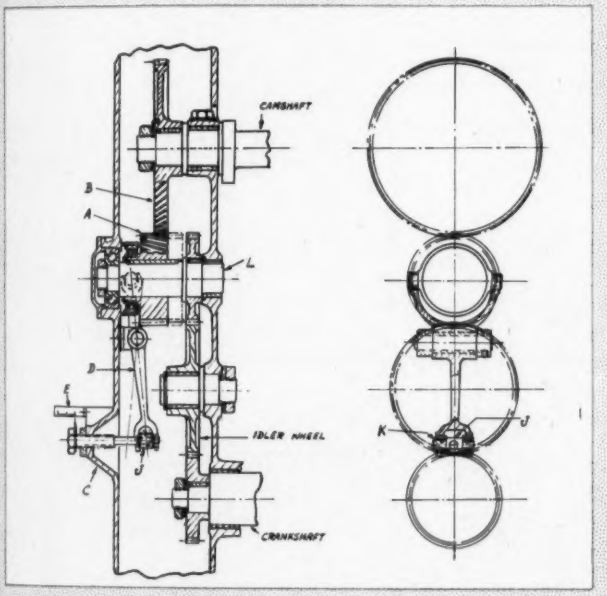
VAVELL SYNDICATE

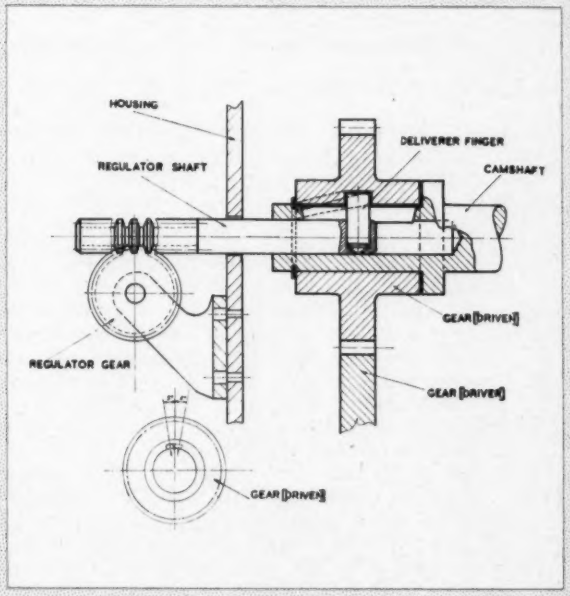
AXIAL DISPLACEMENT OF 45° DOUBLE HELICAL GEAR TO PRODUCE 5° ROTATION $\frac{0{\cdot}5 \cdot 2 \sin 5°}{0{\cdot}0872}$"

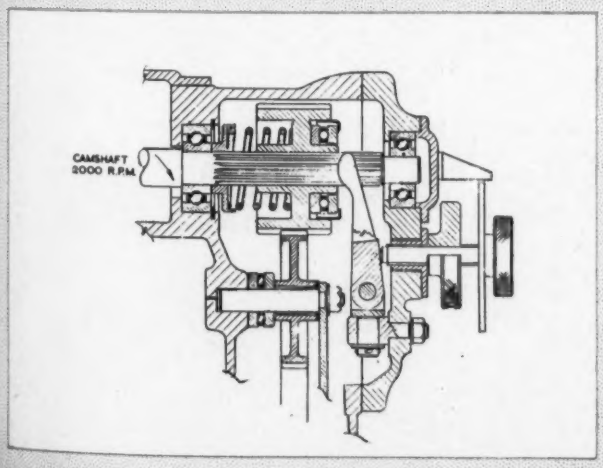
IDLER FACE WIDTH TO ENSURE FULL FACE CONTACT $\frac{0{\cdot}5 + 2 \cdot 0{\cdot}0872}{0{\cdot}672}$"




GEAR MOVED ALONG HELICAL KEYS TO GIVE ± 5° ADVANCE OR RETARDATION TO CAMSHAFT
3 HELICAL KEYS WITH TOTAL OF ±5° TWIST
CAMSHAFT
IDLE GEAR
STRAIGHT KEY
CRANKSHAFT







H.R.HORTON	D.BIGGS
E.CLAYTON	A.P.GONDA
W.S.SPOFFORTH	

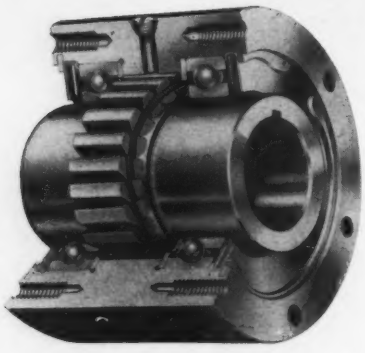


Fig. 1. The Renold all-purpose sprag clutch, available for torque capacities from 95 to 13,500 lb. ft.

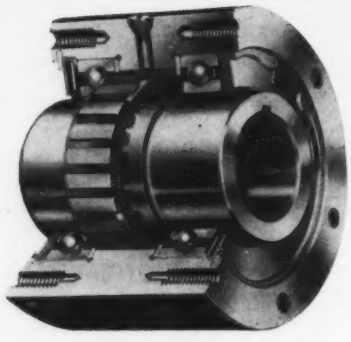


Fig. 2. The Renold high-performance sprag clutch, for applications involving prolonged periods of indexing at rates above 400 strokes/min.

FREEWHEELING DEVICES—PART TWO

In this second part of the survey of freewheels and kindred devices, further particulars are given of the ranges of components available from seven of the principal manufacturers and suppliers

Renold Chains Ltd. (Sprag Clutch Unit)
(*Under licence from Formsprag Co., Warren, U.S.A.*)

The range of backstopping clutches offered by this manufacturer is a large one, and covers clutches transmitting torques from 4·5 to 136,500 lb. ft. The clutches are supplied complete with inner and outer races, some versions having a stub-shaft adaptor. While some types are grease packed for life, others are available without seals for running in oil. In addition to those clutches available "off the shelf", a design service exists for dealing with special applications.

As will be seen in Fig. 1, the sprags in a typical Renold clutch are held in position by a garter spring or springs. The effect of the spring is to exert on each sprag a tilting force which keeps it in light contact with both inner and outer races.

The Renold sprag clutches are supplied complete with plain or anti-friction bearings, thus eliminating some of the difficulty in providing perfect alignment of the shafts. The range offered is too large to describe fully in a survey of this length, but can be summarised as follows.

Light Duty

This is a simple backstop having plain bearings, and is suitable for business machines, home appliances, precision instruments and small industrial machines. Gears, cams, levers, etc., can be mounted on the outer race. The inner race has holes drilled to accommodate a roll pin, suitable drive pins being provided for both inner and outer races. The units are greased for life, and can be supplied for both right- and left-hand direction of drive. Three sizes are available, with $\frac{1}{4}$, $\frac{3}{8}$ and $\frac{1}{2}$ in. bore sizes (the corresponding outside diameters of which are $1\frac{1}{4}$, $1\frac{5}{8}$ and $1\frac{5}{8}$ in. respectively. All are suitable for continuous overrunning at 2,400 r.p.m. The rated capacity of the $\frac{1}{4}$ in. size is 4·5 lb. ft., the other two being capable of transmitting 17 lb. ft.

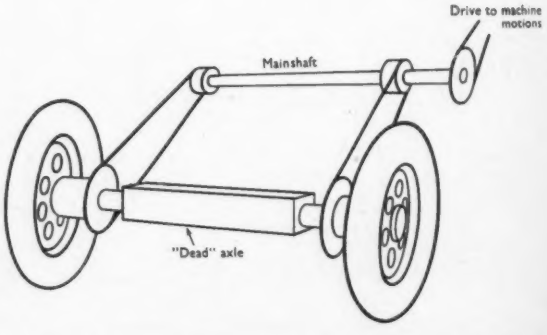
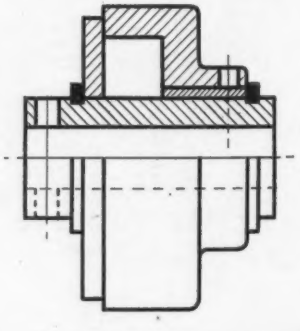
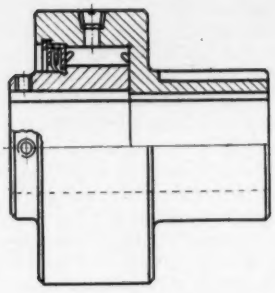


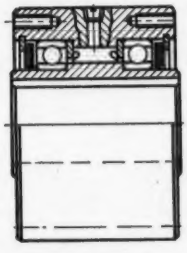
Fig. 3. Suggested application of two sprag clutches for a towed farm machine, one clutch being driven by each land wheel (by means of chain drive to the outer race). Both clutches are mounted on the mainshaft, from which power is taken to the machine motions. (*Renold Information Sheet SIS/5.*)





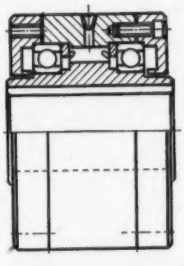
Sleeve Bearing

This series is designed for moderate speed applications. Except for the two smallest sizes, the clutches are supplied with a seal suitable for oil lubrication. All the clutches can, however, be supplied without seals for use when immersed in oil. Bore sizes range from $\frac{3}{8}$ to 2 in., with outside diameters of $1\frac{5}{8}$ to $5\frac{7}{8}$ in. and torque capacities from 15 to 1,310 lb. ft.



All-purpose

This series incorporates two ball bearings, and is suitable for continuous duty overrunning, rapid indexing and backstopping. It is recommended that the associated equipment be mounted on ball bearings. The standard clutches in the series are supplied with seals suitable for oil lubrication, but in some cases grease lubrication should be used. Seals can be omitted when the clutches are immersed in oil. The bore sizes available range from $\frac{3}{4}$ to 6 in., the corresponding outside diameters being $3\frac{1}{2}$ and 15 in. respectively. Torque capacities range from 95 to 13,500 lb. ft.

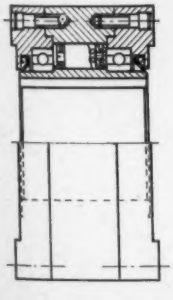


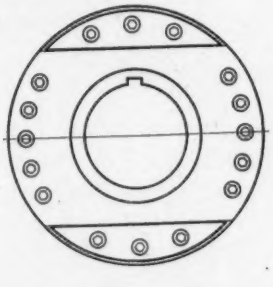
High Performance

Dimensionally the same as the all-purpose clutches, this range has been designed for such arduous conditions as prolonged high-speed overrunning, or consistently high rates of indexing, i.e. above 400 strokes per min. In approved cases these clutches are capable of indexing 1,200 strokes per min.

Flanged Stub-shaft Adaptors

In many cases it is desirable to mount mechanical elements such as couplings, gears, sprockets, pulleys, cams or levers on to the sprag clutch. The part may be of such a shape or size that matching mounting holes cannot be drilled. The stub-shaft sizes range from $\frac{1}{4}$ to $5\frac{1}{2}$ in. dia., with corresponding outside diameters of the clutch unit of $3\frac{1}{2}$ and 14 in. respectively.





Large Bore Backstops

Claimed to be ideal for mounting on the head shafts of large conveyors, this series ranges in bore size from 6 to 12 in., and in torque capacity from 9,000 to 136,500 lb. ft. The end faces of these clutches are gashed to take suitable plate torque arms for anchorage to the equipment structure.

General

In addition to the sizes given in inches, a wide range of Renold clutches are available in metric sizes. In certain instances an American clutch, to slightly different bore and shaft limits, can be supplied.

Reversible Locking Clutch

In addition to the foregoing types of backstop, Renold also manufacture a reversible locking clutch. This device is more sophisticated in conception for, although not providing a freewheel, it can however provide a two-directional drive that eliminates all feedback torque. The component elements of this device are shown in Fig. 4. Input is via shaft *A*, and output from key-way slotted bore *B*.

Between the two ball races, the input member carries a series of projecting control elements evenly spaced around its diameter. Each of these control elements projects between a pair of opposing sprags (see Fig. 4). When the input member is rotated in either direction these control elements first engage one set of sprags at *1* and then drive the output member through the base area *2* of the same set of sprags. A slight motion of the input member of 2½ to 3° is required to release the sprags before transmitting driving torque in either direction of rotation. It is claimed that the wear on the sprags gradually reduces the lost motion. The complement of sprags (arranged in opposing pairs to provide instant wedging against feedback torque) is in reality part of the output assembly, since the sprags are socketed in evenly spaced half-round scallops in the output member. A garter spring, threaded through the centre of each sprag, holds them in a nearly radial position against the outer race. With the sprags in constant contact with the outer race, any independent movement of the output shaft causes instantaneous locking with no backlash on the output shaft. Centrifugal force helps to maintain the lubricant at the point where it is required at the point of relative motion.

Typical applications of the Renold reversible locking

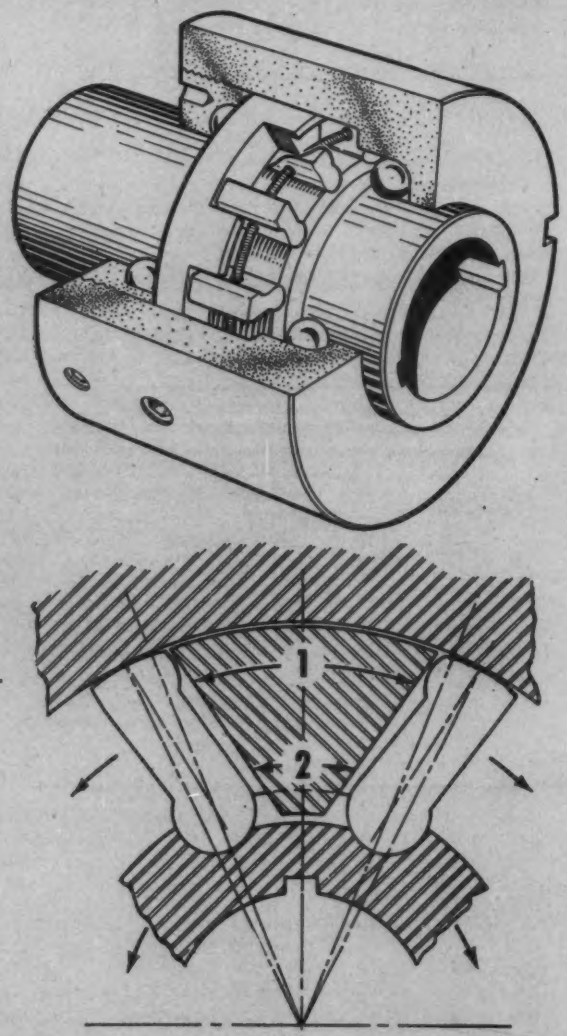


Fig. 4. Component elements of the Renold R-L clutch, a recently introduced device that eliminates feedback torque —it is not a freewheel.

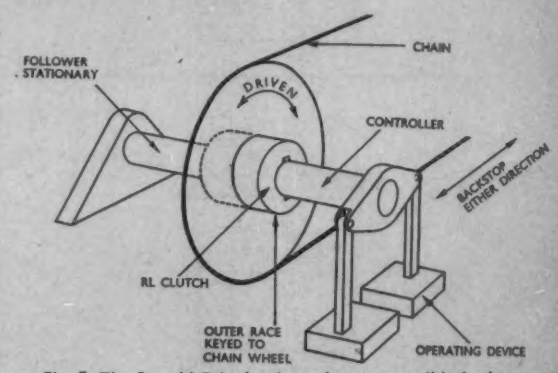


Fig. 5. The Renold R-L clutch used as a reversible backstop.

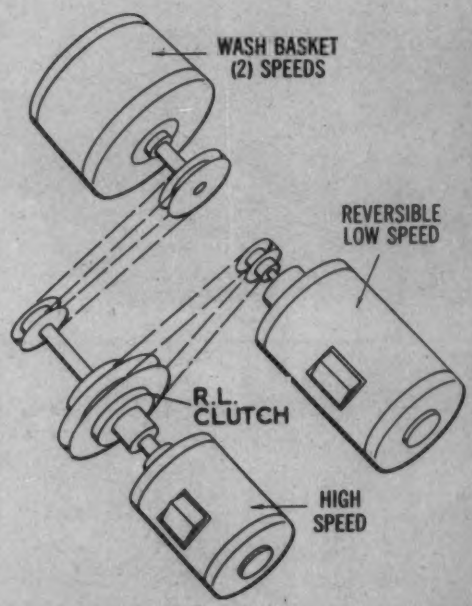


Fig. 6. The R-L clutch being used as a reversible differential overrunning clutch.

clutch are a two-directional overrunning clutch (Fig. 5), and a two-speed drive and reverse (Fig. 6), as in the steering gear of heavy vehicles, such as earth moving equipment (see Fig. 7). An application of the reversible locking clutch as a torque sensing device is shown in Fig. 8. A torque shaft of predetermined "wind-up" is used between the input and output sides of the clutch. This clutch unit is manufactured so that both sets of opposing sprags are normally out of engagement, instead of in engagement with the outer race. In the device shown, the torque shaft between the input and output shaft is designed to carry its rated torque with a wind-up of the torque shaft of less than 6°. When the torque is exceeded, and hence the 6° wind-up is exceeded, the control elements engage one or other set of sprags and therefore transmit all torque to the stationary outer race. In this manner, overload torque is not transmitted to the output member.

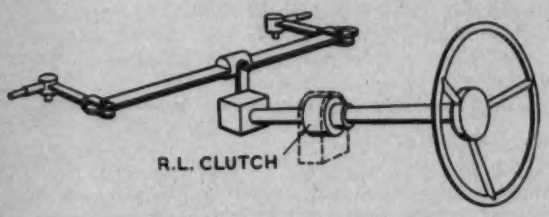


Fig. 7. The R-L clutch used as an anti-feedback device in the steering gear of a heavy earth-moving vehicle.

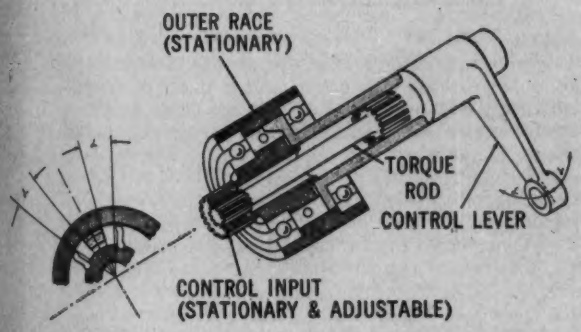


Fig. 8. The R-L clutch in a torque sensing device.

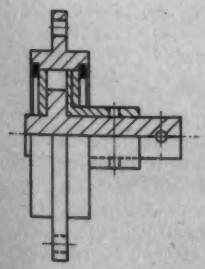


Fig. 9. An example of the smaller sized R-L clutch unit, provided with a flange.

Ringspann

(The sole agents in the U.K. are Henry Pels & Co. Ltd.; the manufacturers are Ringspann Albrecht Maurer KG, Bad Homburg v.d.h.)

The range of freewheels produced by Ringspann employs the cam or sprag principle. The sprags are retained by a garter spring passing through a hole in their centres, versions for heavy duty sometimes employing two such springs. A new version (see Fig. 10), at present available to special order only, replaces the garter spring by a series of individual springs which link each sprag to its neighbour. These springs, which are of a figure-of-eight form, are attached to spigot extensions of each sprag. Greater accuracy of indexing is said to be possible with this new version.

The Ringspann range is suitable for applications involving all three types of duty. The centre of gravity of each sprag lies on an imaginary line between the outer locking point of the cam and the centre of the shaft. This feature is claimed

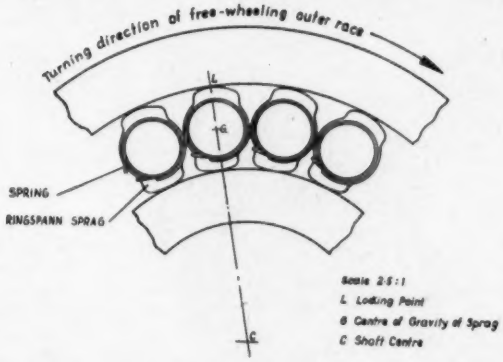
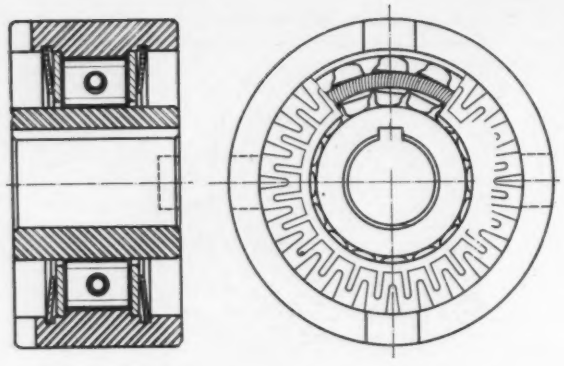


Fig. 10. Diagram showing the principle of a newer type of Ringspann freewheel which is provided with individual springs for each sprag.

to prevent the centre of gravity of the sprag from being displaced by high revs. Free running of the freewheel is thereby maintained, and increase of friction is said to be avoided. Another novel feature is that the freewheel outer race is ground very slightly oval. This is to ensure that the curved surface of each sprag does not gradually develop undue wear at any particular line of contact—the wear is distributed evenly.

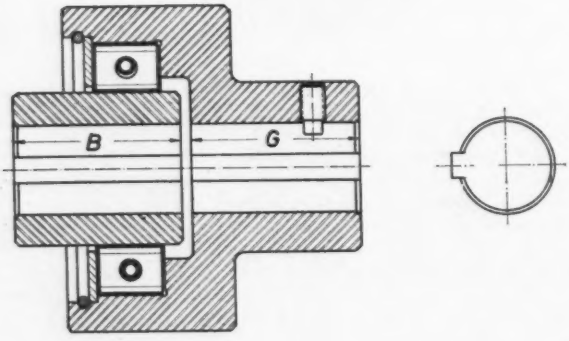
If a freewheel is required which at high speeds will give contact-free running of the sprags, this can be provided by sprags being inserted the opposite way round in the radial sense. In addition, Ringspann now offer sets of individual sprags for applications where the customer wishes to incorporate a freewheel between a shaft and outer race of his own design.



Type RF

This type, which has no bearings, is intended for shaft mounting, the bore of the inner race being provided with a keyway. Adequate bearing support must be provided for the outer race, which is slotted for torque transmission means. Nine sizes are available.

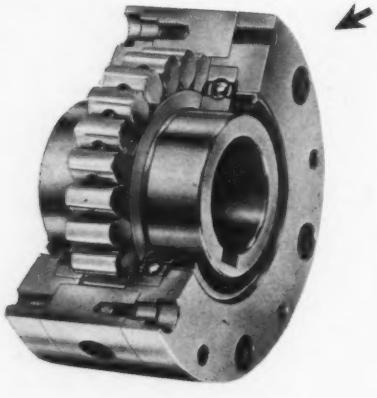
Bore Size	*O.D.*	*Length*	*Permissible Torque*
Min. 14 mm.	55 mm.	38 mm.	4·5 mkg.
Max. 110 mm.	250 mm.	65 mm.	475 mkg.



Type RFW

Designed for interposing between two shafts in line, this type also has no bearings, and these must be provided for the shafts which must be connected. Nine sizes are available.

Bore Size	*O.D.*	*Length*	*Permissible Torque*
Min. 14 mm.	62 mm.	68 mm.	4·5 mkg.
Max. 110 mm.	250 mm.	133 mm.	475 mkg.



Type RFK

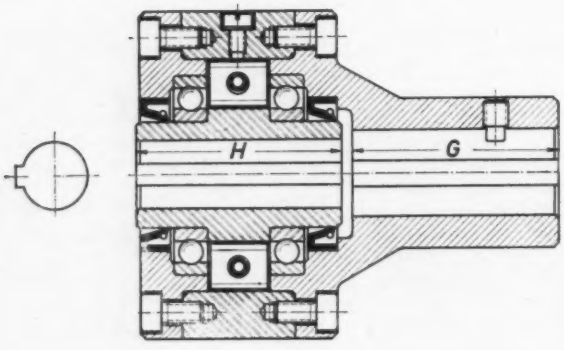
This type is provided with its own ball bearings, and is capable of somewhat heavier duty than the foregoing units. It is provided with oil seals, and eleven sizes are available.

Bore Size	*O.D.*	*Length*	*Permissible Torque*
Min. 14 mm.	75 mm.	48 mm.	8 mkg.
Max. 110 mm.	300 mm.	180 mm.	700 mkg.

Type RFKW

Designed for shafts in line and somewhat similar to Type RFW, only provided with ball bearings, this type is well suited to applications where the freewheel must be interposed between two shafts, one of which is supported and the other not. Eleven sizes are available.

Bore Size (Max.)	*O.D.*	*Length*	*Permissible Torque*
Min. 14 mm.	75 mm.	98 mm.	8 mkg.
Max. 110 mm.	300 mm.	363 mm.	700 mkg.



Type KG

This freewheel, which is also fitted with ball bearings, resembles Type RFK, but is different in that it is provided with a flange for fitting, and two garter springs are used to retain the sprags. Eleven sizes are available.

Bore Size	*O.D. (Body)*	*O.D. (Flange)*	*Permissible Torque*
Min. 14 mm.	75 mm.	105 mm.	8 mkg.
Max. 110 mm.	300 mm.	365 mm.	680 mkg.

Types RFKL and RFKWL

In addition to the foregoing, Ringspann also offer a range of freewheels which incorporate a freewheel and flexible shaft coupling. The freewheel part of these combined units is equipped with ball bearings, as in the RFK type. With these units, shaft misalignments of up to 3°, and up to 5 per cent of the shaft diameter, can be tolerated.

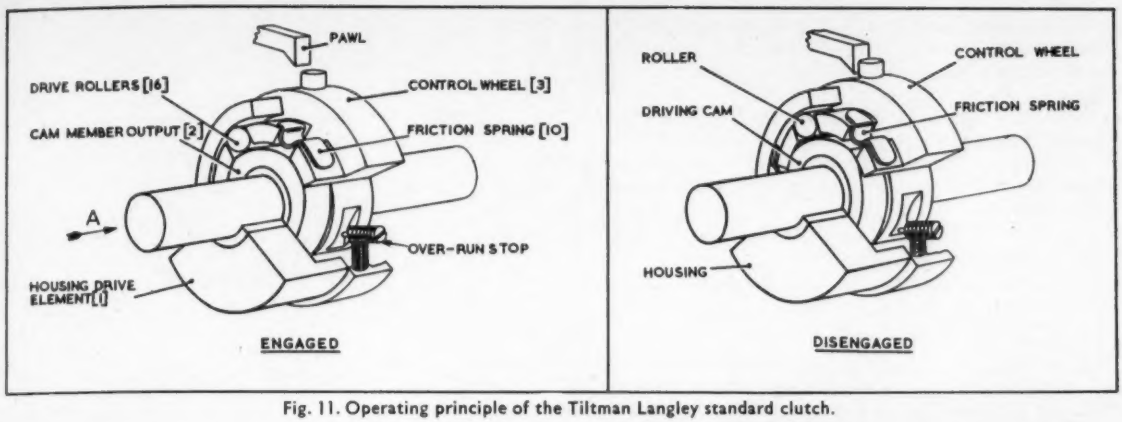


Fig. 11. Operating principle of the Tiltman Langley standard clutch.

Tiltman Langley Ltd.

This company produce a clutch, a freewheel, a dual-drive and a backstop—these are offered in a miniature range. In addition, there is a clutch freewheel hold-back in one unit, and also a combined pulley-freewheel unit, both of larger size. The miniature sizes of clutch, freewheel, dual drive and backstop are available in the form of a kit supplied in a box, and are intended to supply the needs of engineers engaged on the building of prototype equipment. With the parts supplied in the kit, it is possible to build any of the above four types of unit without the assistance of a drawing office. These units, when assembled, operate as follows:

Clutch

The housing *1* (see Fig. 11) is the driving member, and is shown driving in an anti-clockwise direction. The right-hand sketch shows the clutch disengaged. When the control wheel *3* is held stationary by operating the pawl, it prevents the rollers *16* from being driven into the wedge formed by the housing and cam *2*, i.e. the driven member.

When the pawl releases the control wheel (see left-hand sketch), the control wheel is moved anti-clockwise due to the friction spring *10* between the control wheel and housing, and thus the rollers are driven into engagement. On stopping the control wheel the rollers are forced out of engagement, and the clutch reverts to the disengaged condition (see right-hand sketch).

When the clutch is disengaged, i.e. the control wheel is stationary, the driven member or cam is prevented from overrunning by the concave recess coming up against the set-screw in the control wheel. This overrun is adjustable (minimum overrun is 1°). For clockwise rotation the positions of the pawl, teeth and set-screw are reversed.

CONTROL SYSTEM—The control of the clutch as shown is by a pawl engaging with a tooth in the control wheel. With one tooth one or more full revolutions of the output shaft

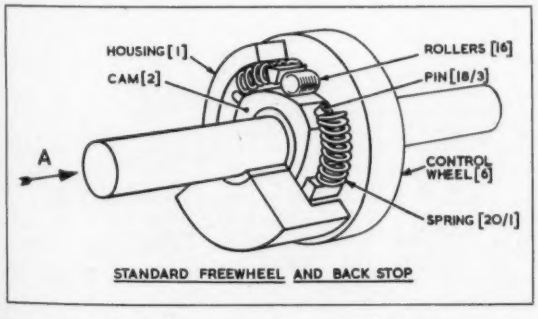


Fig. 12. The Tiltman Langley standard freewheel and backstop.

Type 112 standard kit.

are possible, according to the frequency of pawl engagement. Multi-teeth will give fractions of a revolution. The operation of the pawl may be by either electrical, mechanical or hydraulic means.

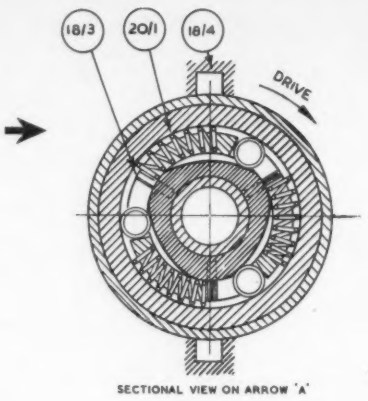
Freewheel and Backstop Unit

FREEWHEEL—The housing *1* (see Fig. 12) is normally the driving member, and the control wheel *6* holds the rollers *16* into the wedge formed by the housing bore and cam *2* by the reaction of the spring *20/1* on the pin *18/3* and control wheel dog. When the housing rotates in the same direction as the control wheel spring force, engagement takes place and the drive is transmitted through the cam which is the output member.

If the cam rotates faster than the housing, the wedging action is relieved and freewheeling takes place; similarly, if the drive is stopped the cam is free to rotate independently of the housing. The cam, however, can be the driving member, the freewheel action being as described above, except that the rotation is reversed. There are certain speed limitations when employing this method.

The rollers make non-slip driving contact, but will "roll out" of engagement and release instantly without shock. The actual roller movement, from engaged to disengaged position, is so small that back-lash is said to be negligible.

BACKSTOP—The essential components are the same as for the freewheel (see Fig. 12), with the addition of two pins *18/4* fitted to the housing. These two pins when fixed in space provide a means for holding the housing stationary, and as the spring force acts on the rollers in the direction of rotation of the cam, the wedge action is relieved, thereby allowing freewheel action. However, on reversal of the cam or output drive, the cam forces the roller into the wedge formed by the cam and housing bore, thus preventing reverse rotation.



Dual Drive Unit

The housing *1* (see Fig. 13) is the primary drive member and the control wheel *6* is the secondary drive member. In the static condition, the three springs *20/2* force the six rollers *16* into the two wedges of each cam, and with the primary input member the cam *2* is locked from rotating in either direction.

PRIMARY DRIVE—(See sectional view.) On turning the housing in either direction the leading rollers are assisted into the wedge by the spring, and therefore drive the cam, the trailing rollers being rolled out of the wedge by the friction of the housing and freewheeling taking place. Thus for clockwise rotation, rollers *A* drive and *B* freewheel; for anti-clockwise rotation, rollers *B* drive and *A* freewheel.

SECONDARY DRIVE—(See sectional view.) On turning the control wheel in either direction, one set of three dogs *X* on the control wheel engage with the pins *18/3* fitted to the cam, and at the same time the opposite set of three dogs *Y* engage a set of rollers *B* and move them out of the wedge, thus releasing the lock and allowing the three dogs *X* to turn the cam by way of the pins. Thus, for clockwise rotation of the control wheel, dogs *X* engage the cam pins and at the same time dogs *Y* move rollers *B* out of wedge, and as rollers *A* are in the freewheel condition the cam or output member turns clockwise; for anti-clockwise rotation the procedure is reversed.

The primary drive and the lock on the driven member are absolutely positive, but on the secondary drive there is said to be a small amount of backlash as the dogs take up the drive on the pins.

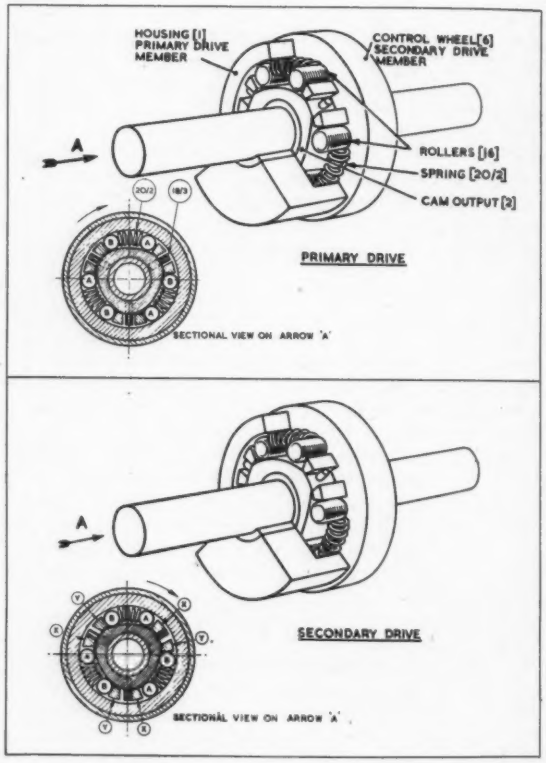


Fig. 13. Operating principle of the Tiltman Langley dual drive unit.

Direction of Rotation

Rotation is defined when looking on arrow *"A"* in Figs. 11, 12 or 13, i.e. on item *1*, the back end of the housing. The clutch, freewheel and backstop units can be assembled for either clockwise or anti-clockwise rotation. It is possible, however, for the driving member of the freewheel to drive in one direction and freewheel in the other, as in a rachet application.

For the dual drive rotation of primary or secondary drives, these may be in either direction according to requirements. The various alternative types of drive possible with the kit are shown on the facing page.

Sizes and Ratings

The miniature units described are designed for use with a $\frac{1}{4}$ in. dia. shaft. Other dimensions are given in Fig. 14. The clutch and freewheel can transmit up to 0·5 h.p. (20 lb. in.) at 1,500 r.p.m., depending on the nature of the load. Maximum load for short duration is 100 lb. in.

In addition to the foregoing miniature range, Tiltman Langley also offer a clutch, freewheel and hold-back in one unit, and a combined pulley-freewheel unit. Particulars of these units are given in Figs. 15 and 16. The pulley-freewheel unit enables two standard motors to be used instead of a two-speed motor.

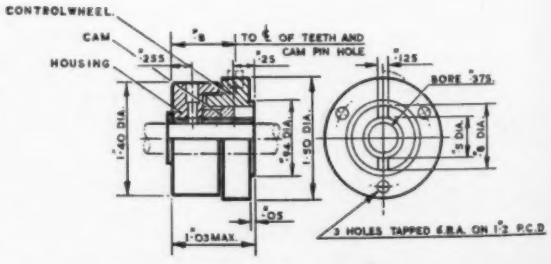
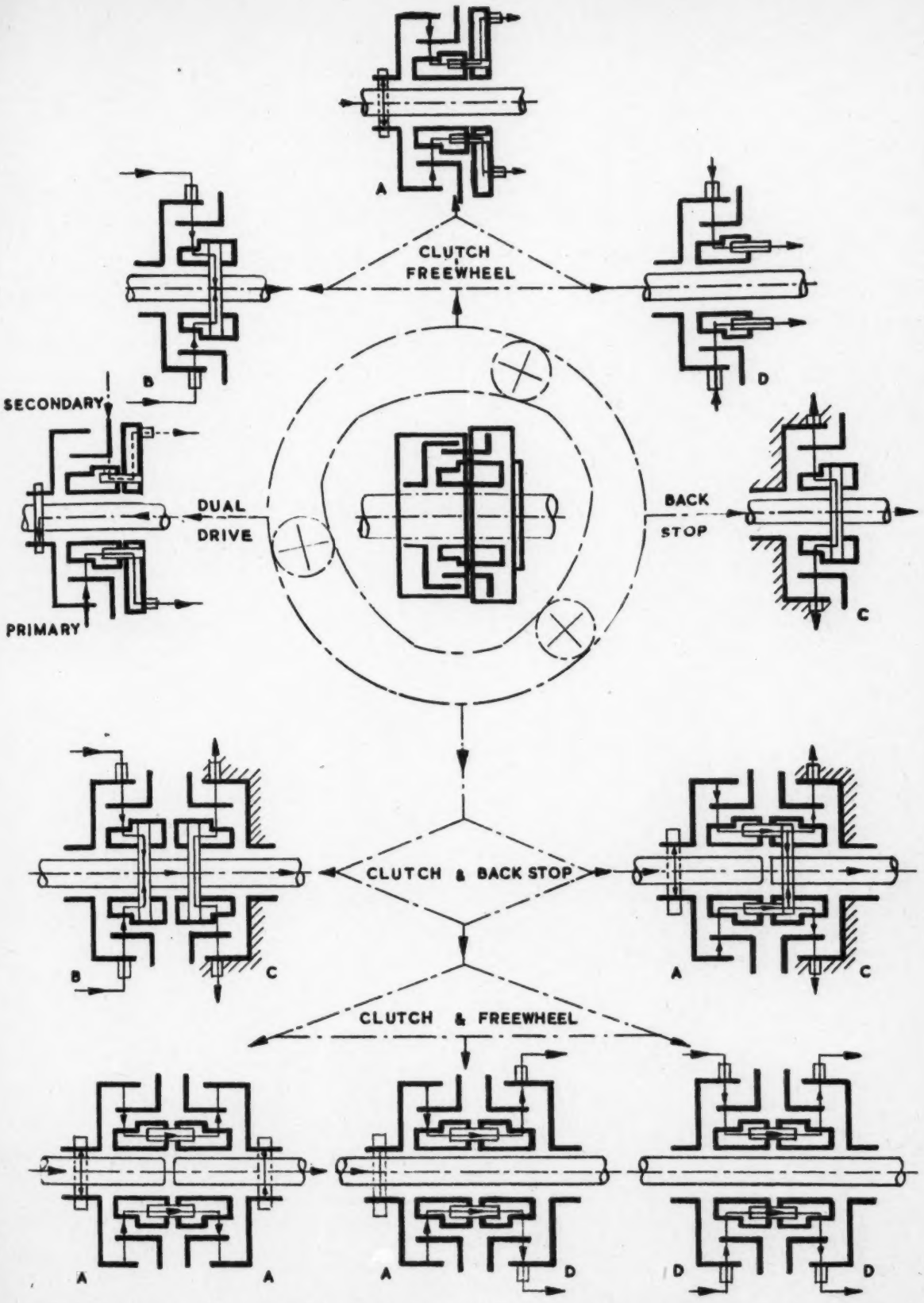


Fig. 14. Dimensions of the Tiltman Langley range of small clutch units.



DRIVES THAT CAN BE ARRANGED WITH THE TILTMAN LANGLEY TYPE 112 KIT

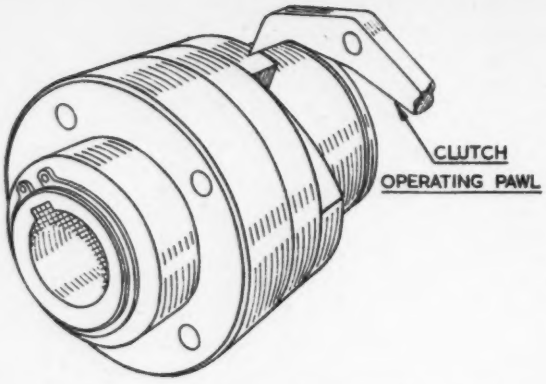


Fig. 15. The Tiltman Langley clutch, freewheel and hold-back unit.

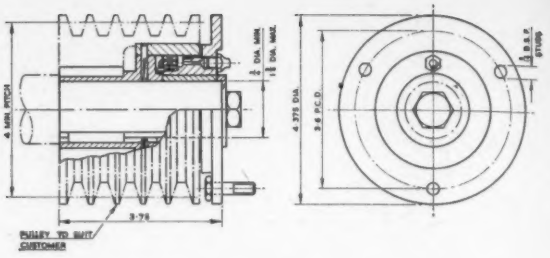
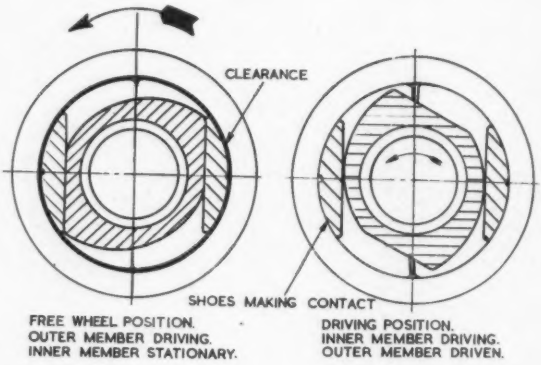


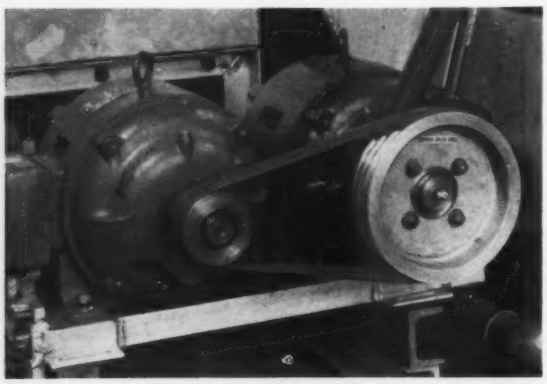
Fig. 16. The Tiltman Langley combined pulley-freewheel unit.

R. G. Whitaker Ltd

The overrunning clutch made by this company, who are well known in the laundry machinery field, was developed originally for a rotary dry-cleaning machine (see photograph). The original version of this machine employed a two-speed electric motor, and it was decided that, from the standpoint of maintenance, it would be better to use two standard motors, one of which would carry an overrunning clutch within the V-belt drive pulley. Although this is a fairly standard application for other types of overrunning clutch as mentioned in this survey, for reasons of economy it was decided to develop the very simply made clutch shown.

The clutch (see Fig. 17), which is fitted within the bored recess at the end of the smaller V belt pulley, consists of a hardened steel cam bolted to the larger pulley, and two phosphor bronze shoes which are forced apart by the cam





The Whitaker overrunning clutch as applied to a rotary dry-cleaning machine.

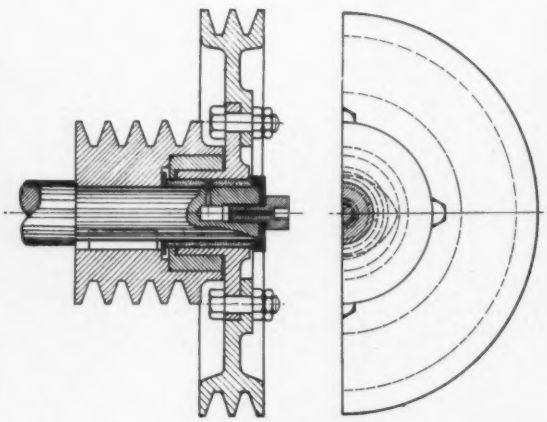


Fig. 17. Operating principle of the R. G. Whitaker overrunning clutch.

against the wall of the bored recess. In the freewheel state, drive is direct from the smaller pulley to the cleaner drum at high speed, and the two phosphor bronze shoes come away from the bore of the pulley. In the slow speed state, partial rotation of the larger pulley relative to the smaller one enables the cam to force the two shoes apart, thus enabling torque to be transmitted from the larger to the smaller pulley.

This simple overrunning clutch has been found trouble free in the arduous conditions in which it is used, and runs without lubrication. It is not at present manufactured, except to order, every application requiring special investigation. Several successful variants of the principle have been produced. It would not be suitable for indexing, however, owing to the fairly large angle through which the cam must move before locking occurs.

Addresses of the Manufacturers and Suppliers in this Survey

Borg-Warner Ltd., Letchworth, Herts.
Machine Shop Equipment Ltd. (sole Concessionaires for Stieber Rollkupplung KG, Heidelberg), 14-28 Spenser Street, London, S.W.1.
Padomatic Ltd., 12 Cavendish Avenue, London, N.W.8.
Renold Chains Ltd., Renold House, Wythenshawe, Manchester.
Ringspann (sole agents in U.K. are Henry Pels & Co. Ltd., 32/8 Osnaburgh Street, London, N.W.1.
Tiltman Langley Ltd., Redhill Aerodrome, Surrey.
R. G. Whitaker Ltd., Portland Road, Kingston-on-Thames, Surrey.

Error in the June issue. We regret that, in the range of freewheels offered by Machine Shop Equipment Ltd., the NF and NFR Series illustrations (p. 357) were inadvertently transposed.

GLASS—ITS ROLE IN POWDER METALLURGY

Sintering under glass can be used to produce metal-glass combinations with interesting properties, or as an alternative to vacuum sintering or vacuum hot pressing of loose powder or powder metal compacts

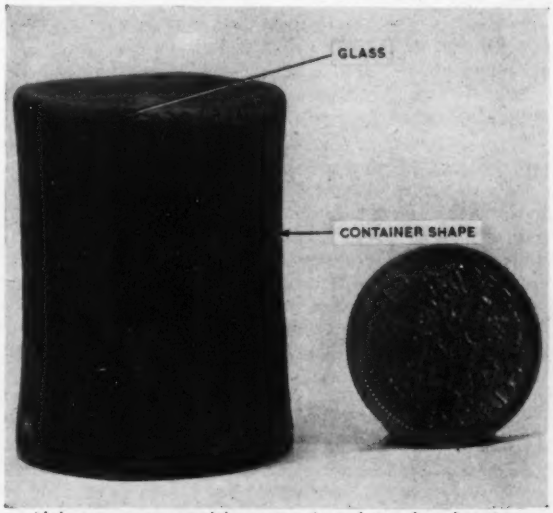
by D. YARNTON and D. K. HILL *

RECENTLY the process of sintering under glass was developed by the authors in conjunction with M. Argyle.[1] This showed that it was possible to sinter reactive metal compacts without the use of vacuum by immersing them under molten glass at the appropriate sintering temperature. The nature of the product depended on whether or not the compact was infiltrated. In such a case a glass-metal combination resulted, and where no infiltration occurred bright sintering was noted.

Metal-Glass Combinations

The use of glass for industrial purposes is relatively new compared with its use for glazing or packaging. As a result of several decades of research by both the glass and metallurgical industries its fields of use have been extended so as to embrace high-temperature lubricants for hot extrusion of metals, as well as new materials developed for mechanical purposes requiring high thermal endurance. Other applications are in the electrical and electronic fields. Not the least of these developments is the use of glass in combination with metallic materials.

A variety of glasses are available resulting from the fusion of various oxides, most commonly including those of silicon, potassium, boron, magnesium, aluminium and lead in different proportions. The entire range of glasses, however, includes almost all the elements of the periodic table. By its very nature, glass is extremely corrosion resistant to nearly all materials other than alkalis or fluorides, while it is hard and possesses high electrical and thermal resistivity. As normally prepared its greatest disadvantage is its brittleness, resulting in low mechanical strength. Metals have properties practically the opposite to glass. Obviously, a combination of the two would produce a wide variety of properties, especially in so far as there is as wide a range of glass composition as there are of metallic alloys. These variations can be further extended by altering the nature and degree of dispersion of either glass in metal or metal in glass. To date the use of glass in conjunction with metals is a relatively unexplored field, but one to which attention is being increasingly directed. One of the earliest applications was glass to metal seals.[2, 3, 4] In this context there has been a wide body of experience, but many potentially interesting lines of development appear to have been neglected. Recently, however, conducting metal coatings for de-icing aircraft,[5] and insulated metallic conductors for de-icing roads, have been developed. The main line of glass-metal combinations has been relatively restricted to surface coatings of one on the other, but the application of techniques similar to those used in the powder technology field has been limited. Some applications in this direction have been products made from powder, cellular or foam glass for use in heat or sound insulation for buildings and cold stores. Others have been the development of chemical filters and moderately high temperature equipment, slip casting methods having allowed the range in size and form of articles to be extended.



Alnico magnet material, pressureless sintered under glass.

* *Mr. Yarnton is senior lecturer in powder metallurgy at the College of Technology, Rotherham, Yorks. Dr. D. W. Hill is deputy director in the British Glass Research Association Laboratories at Sheffield.*

Dispersed phase hardening of materials has been the subject of much investigation recently. The reason has been that dispersion of finely divided phases retards the processes of deformation and re-crystallisation of a metal, resulting in an improvement in its low and high temperature properties. The extent of improvement is related to many factors, particularly the mode of dispersion. This can take the form of colloidal dispersion throughout the matrix, or precipitates or films at the grain boundaries. While oxides, nitrides, borides, metals and intermetallic compounds have all received considerable attention, the use of glass has been neglected despite the fact that it is inexpensive and available in the molten, powder or fibre state. As metals are also available in the same three forms, the variety of modes of dispersion of one with the other enable a range of properties to be available from one specific composition. This range can be further extended by the incorporation of nucleating agents affecting the properties of glass or metal.

In general, mechanical or physico-chemical methods of dispersion are used. A wide choice is available, including mixing, milling, flame-spraying, ultrasonic dispersion, atomisation, evaporation, precipitation, vaporisation-condensation, electrolysis, infiltration or liquid phase sintering.[6] The methods may be used alone or in combination. The main aim is to achieve the required form and degree of dispersion in as uniform and economic manner as possible. Generally, whatever method is used, further processing such as casting, hot rolling or extrusion, pressureless sintering, compaction and sintering, reduction or forming into cloths or porous mats may be necessary.

Mechanical mixing of powdered glass and metal powder or oxide[7] is the simplest and most versatile method, but, due to the mechanics of mixing, segregation may arise. The degree and form of dispersion may not be ideal but by milling the particle size and shape of both glass and metal may be altered. It is feasible, also, that ductile conducting materials may be smeared around individual particles if milling conditions are correct. Once the technique is established the processes are easy to control, but generally the degree of dispersion is not minimal.

The incorporation of metal in glass melts or vice versa offers an alternative process. For instance, in the production of glasses with high ultra-violet transmission it is common to add metallic aluminium, while nucleating agents such as noble metals may be added to produce colours. Thus, ruby coloured glass is produced by colloidally dispersed gold or copper, while silver produces yellow-brown glass. Recent developments include ultrasonic dispersion of constituents throughout metallic melts.[8, 9] The resultant melt containing dispersed glass or metal can be cast, atomised or otherwise treated. An interesting possibility is the production of low-eddy current cores or magnets with high-electrical resistivity, where a high proportion of ferro-magnetic phase is dispersed in glass.

Several methods are available for the production of surface coatings. A flame spraying technique[10] has been recently developed for producing de-icing equipment, copper-manganese alloy being sprayed on to a glass fibre plate. The reverse process is also feasible, while enamelling technique is well known. The use of resinates for firing gold, silver or platinum on the surface of glass is well established, and applied to the production of printed circuits for electronic application. Evaporation-condensation techniques are also becoming increasingly important. A notable example is the condensation of vapours from fused ferric chloride or tin salt. The coating of glass fibre has been developed where electrically conducting coatings can be produced by heating the fibres above the decomposition point of the vapour of the metallic compound.[10] An alternative method is to pass the fibre through a bath containing a suitable solution of fused salt. The importance of such fibre materials can be gauged from the fact that glass fibres have been produced with tensile strength of 2×10^5 p.s.i.

Vacuum techniques extend the range of possibilities, so that transparent but electrically conducting glass surfaces can be produced by evaporation and condensation *in vacuo*. Articles so prepared can be used for de-misting or de-icing, and make feasible the whole field of electro-luminescence. Some experience has also been gained in evaporating and condensing glass on metals, to give surface protection.

Two reports reveal that the U.S.S.R.[11] has developed a technique for producing glass-coated super-fine metal wires 1 micron in diameter. Deposition of metal coatings has also been obtained by the effect of gaseous hydrogen on an ammoniacal solution of a metal salt at a controlled temperature and pressure.[12] Alternatively, evaporation of metallic salts on to fibres is possible, followed by heating first under oxidising and then under reducing conditions to convert to metal form. Electro-plating methods have been developed where glass fibres are plated with copper or other metal for conversion into battery plates.[13, 14] The production of metal patterns on glass is similarly achieved for printed circuits.[15, 16]

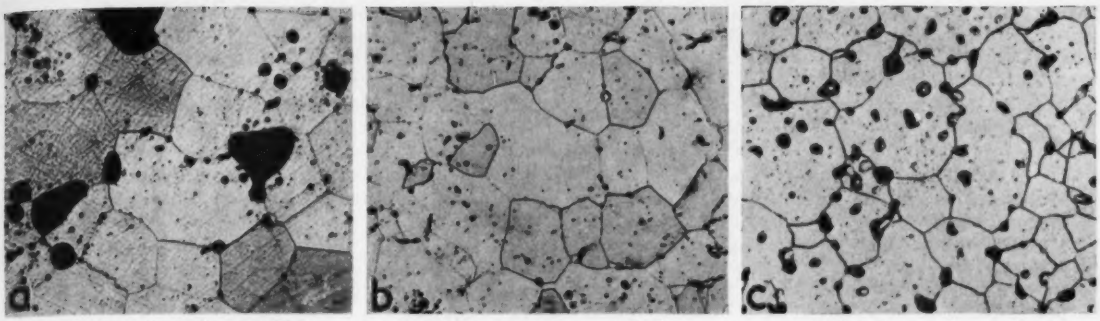
Liquid phase sintering is another possible process of dispersing metal throughout glass or glass throughout metal. This technique involves sintering at a temperature above that of the lower melting point constituent. Thus, according to the melting point of the metal and the viscosity-temperature relationship of glass, either the metal or glass will permeate and bond the other. The essential condition is that wetting must take place.

As previously stated, infiltration of a porous metal compact by glass proceeds when wetting conditions are achieved.[1] In the production of metal-glass combinations the procedure of sintering under glass serves two purposes simultaneously. It avoids the use of the controlled atmosphere normally essential for sintering metal compacts, while the glass also acts as the infiltrant medium. The research procedure adopted initially was to melt the glass in a crucible, immerse the compacts, and to sinter at the appropriate temperature. Infiltration proceeded, a glass-metal combination resulting, and the glass partially or wholly penetrating so that a case-hardened surface was obtained. Bright sintering also resulted due to the slagging effect of the glass. The proportion of glass and its mode of dispersion could be readily varied by altering the compaction pressure particle size or sintering conditions. Some properties are quoted in Table 1.

Alloys so treated showed considerable improvement in surface hardness and oxidation and corrosion resistance. Iron powder compacts sintered under glass were cold short but readily hot rolled, giving a glassy corrosion-resisting surface, up to 40 per cent by volume of the glass being readily incorporated and tolerated. The compacts of high glass content showed remarkable properties for bonding with glass such that the resultant glass coatings could not be removed by hammering, boiling in fused caustic soda being necessary. The alloys thus seem to have a feasible use in moderately high temperature conditions, for metal to glass seals as well as for electrical applications.

Sintering under Glass

The process of sintering under glass is also a possible alternative to vacuum sintering, while modifications of the process could render it suitable for hot pressing or hot extruding reactive materials. Normally, the large surface areas possessed by metallic powders make them prone to rapid oxidation, while reactive materials are subject to the danger of spontaneous combustion. As a result the sintering of metal powders is generally achieved under a reducing atmosphere, control being directed to exclude oxidising gases by catalysis and drying. Despite such precautions certain materials containing reactive elements are still subject



A—Vacuum sintered at 1,340°C. for 90 min. (×300.)

B—Glass sintered at 1,340°C. for 45 min. (×300.)

C—Nickel-glass alloy sintered under glass. (×500.)

Photo-micrographs of cylindrical Alnico magnets.

Table 1. Properties of a glass-metal combination.

Mix	Pressure (t.s.i.)	Treatment	Max. Stress	% Elong.	VPN		Sinter Density (gm./cc.)
					Case	Core	
Electrolytic Fe powder 1% graphite	30·0	Glass sinter 30 min. 1,250°C.W.Q.	35·6	1	310	130	6·61
		Vacuum sinter 30 min. 1100°C., repress 30 t.s.i., glass sinter 30 min. 1,250°C.	42·5	2	224	150	7·00
		Vacuum sinter 30 min. 1,100°C., repress 30 t.s.i. Vacuum sinter 30 min. 1,250°C.	29·1	5	139	127	7·05
Low Ni-Mo Steel	35·0	Sinter cracked ammonia 1 hr. 1,250°C.	35·5	2	156	—	6·76
		Vacuum sinter 1 hr. 1,300°C.	35·4	7	158	—	6·97
		Glass sinter 1 hr. 1,250°C.W.Q.	24·2	1	300	160	6·63

Courtesy of Sheepbridge Engineering Co., Chesterfield.

Table 2. Cylindrical compacts—Alnico II magnets

Treatment	Temp. (°C)	Time (min.)	G.D. (gm./cc.)	S.D. (gm./cc.)	Magnetic Properties		
					B rem.	BH × 10^6	H
Vacuum	1,340	90	5·63	6·70	7,180	1·620	580
Glass	1,340	15	5·64	6·73	7,250	1·530	510
	1,340	45	5·63	6·78	7,250	1·595	555

Table 3. Rectangular compacts—Alnico II magnets

Treatment	Temp. (°C.)	Time (min.)	G.D. (gm./cc.)	S.D. (gm./cc.)	Magnetic Properties		
					B rem.	BH × 10^6	H
Vacuum	1,340	90	5·63	6·85	6,950	1·600	620
Glass	1,340	5	5·58	6·55	6,900	1·380	475
		30	5·55	6·70	7,000	1·670	580

Values taken from reference 17.

Table 4. Pressureless sintered Alnico II magnets

Mode	Temp. (°C.)	Time (min.)	S.D. (gm./cc.)	Magnetic Properties		
				B rem.	BH max.	H
Vacuum	1,340	90	6·97	7,000	1,600	590
Glass	1,340	30	6·56	6,600	1,450	600
Glass	1,340	90	6·90	6,850	1,490	610

Values taken from reference 17.

to oxidation, and vacuum sintering is necessary not so much to de-gas the material as to exclude the atmosphere. Such a process is expensive, while limitations are imposed on both size and output. Any possible alternative is obviously worth investigation.

For infiltration to proceed, wetting of the compact by glass is necessary. It was noted that alnico magnets and titanium powder compacts were not subject to infiltration by glass, whereas those of iron, nickel and stainless steel were. In the case of the former, bright sintering resulted although de-gassing did not take place. The main materials requiring vacuum sintering are tantalum, zirconium, beryllium, titanium and magnet material. Initial experiments were therefore, directed to the latter material.[17] A series of compacts of rectangular and cylindrical form were prepared from pulverised cast material of which the composition was 15·5 Co, 16·0 Ni, 5·5 Cu and 9·5per cent Al (balance iron). Samples were then sintered under molten glass for periods varying from 5 to 90 min. at a temperature of 1,340 deg. C. The process used was to preheat bottle glass in a Battersea crucible to 1,200 deg. C., using an electric furnace. The crucible and contents were then removed, one or more compacts immersed and the whole transferred to another furnace at 1,340 deg. C. After the appropriate soaking period the relevant crucible was partially cooled and then water quenched. The compacts were then separated from the glass and subjected to the appropriate heat and magnetic treatments for the alloy concerned. The compacts were then examined, and the shrinkage, density and magnetic properties of each individual compact compared with a control set of compacts which had been vacuum sintered instead of glass sintered. The microstructures of all the compacts were also compared. Typical results are set out in Tables 2 and 3.

It can be readily seen that except for the coercivity values there is little to choose between either method, and that on a research scale at least, glass sintering is a possible alternative.

Further experiments were then proceeded with regarding the sintering of loose powder under glass—technically termed pressureless sintering. The latter process enables billets or forms to be processed without the use of compaction, which often involves large capacity presses, the pressure of compaction in many cases approaching 50 t.s.i. For many purposes the production of a billet which can be hot rolled, forged or extruded to shape is required, but where vacuum sintering is involved size is a considerable factor. Preliminary experiments showed that the best form of glass receptacle to use was one which was self-sealing, i.e. one which had a narrow-necked orifice through which powder could be fed into a glass container of the desired shape. The process was to fill the container with the appropriate powder mix and then embed it in glass chips in a crucible. The whole was then slowly raised to temperature in a crucible furnace. The orifice allowed gas evolution to proceed without air ingress. By the time the glass had softened, the powder had densified sufficiently to retain the original shape of the container. Simultaneously, the orifice sealed off and, as the glass contents of the crucible melted, sintering under glass proceeded normally. Initial results showed that the properties of pressureless sintered magnet material approached those of compacted vacuum sintered material. Presumably an increase in the time at temperature might lead to further improvement. Some values are given in Table 4.

Such a process could obviously be applied to other materials requiring vacuum sintering, with certain restrictions.

A further adaptation of the process is possible. For instance, certain materials require hot pressing *in vacuo*—this is a complicated process and by no means inexpensive. Preliminary experimental results show that even under pressure wetting is not achieved, and that hot pressing of materials in glass containers in graphite dies is a possible process, as is the hot extrusion of powders in glass. Thus for alnico magnet material hot pressed at 1,340 deg. C. under a pressure of 1 t.s.i., a density of 7·15 gm./cc. was achieved, bright sintering resulting.

The general conclusion is, therefore, that the use of glass in the powder metallurgy field has a promising future, either in the formation of metal-glass combinations or in the sintering, hot pressing or extrusion of reactive materials. Whether on a research or practical scale, further investigation is merited.

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STAEDTLER SCHOLARSHIP FOR DRAUGHTSMANSHIP

ENGINEERING students in their last year at technical colleges and schools throughout Great Britain are being invited to compete for a newly endowed scholarship. Known as "The Staedtler Scholarship for Draughtsmanship", with a post-graduate course at a German technical university as the principal award, this scholarship is sponsored by J. S. Staedtler Ltd., suppliers of drawing pencils. All fees, together with travelling costs and board and lodging, will be paid. Provision will also be made for language tuition if the successful student is without a working knowledge of German. The alternative first prize is a cash grant of £250 to assist with post-graduate study in Great Britain. There will be a second prize of £100 and a third award of £50.

Awards will be made for the quality of draughtsmanship, combined with the most outstanding design. Students of engineering may submit designs for the future development of the railway train, or some method for dealing with the problem of ground transport. Those interested in the use of solar energy, and similar ideas, may design the house of the future. To provide an all-round opportunity for promising designers, students of architecture also have been invited to take part.

Entry forms and full details may be obtained from college and school principals. The drawings can be sent in at any time, but must be received by the judges not later than Friday, July 14, 1961.

LETTERS TO THE EDITOR

Elimination of Exhaust Fumes

Sir,

We thank you for drawing our attention to your article headed "Elimination of Exhaust Fumes" (p. 304, May 1961). We would like to point out that we now have available, in addition to the mufflers for use on unleaded petrol, a new design of muffler which has been developed by our French associates, using a new type of pellet catalyst which is now available for use on leaded petrol.

A. Aikens

Oxy-Catalyst Sales Ltd.,
Bookham, Surrey.

Encouragement of Originality

Sir,

Thank you for publishing Mr. F. Gordon Pratt's interesting and analytical letter (p. 297, May 1961). One particularly agrees with the vital need for original thinking, today more than ever, and the virtual impossibility of pre-assessing individuals in these terms; also the urgency of encouraging this quality if we are to survive in the future, let alone lead the world again. Why have we not kept pace with our past, from which we inherited the profound advantages of leadership already won? Has our natural aptitude really died? I think not.

By past example we did much to teach the world to think constructively, but now seem content (perhaps inadvertently) to frustrate it here. All too often the man who conjures up new and important developments or improvements is met with a frown by manufacturers, who either seem blind to their true possibilities or merely resent the effort of re-tooling while comfortable demands still exist for older products. Yet when the improved article ultimately reaches production, the sales staff, rather than those whose ingenuity created it, tend to get the rewards. The reasons for this could be analysed but would take too much space.

Because the issue is fundamental to our future, it demands investigation and correction. For a solution to one aspect of the problem I am inclined to revert to an inspired observation from you, Mr. Editor, when you suggested an Independent National Research Corporation (p. 69, February 1960). The National Research Development Corporation tackles but a fraction of what is being lost—and that the most technical, the most costly and involved to develop, and often the least readily commercialised or rewarding sector—while shoals of less elegant but far more easily implemented and profitable developments get lost. This waste continues.

Our capacity for creative thought, invention, original and progressive design is as great as ever, nor do we by any means lag everywhere. But red tape, vested commercial interests, the welfare-state mentality, the parochial outlook of too many manufacturers, taxation procedures in the case of the independent man, costing procedures in the case of some firms, the attitude of both lay public and (alas) some experts to "new things", the lethargic or disparaging frame of mind of many politicians—these and a host of kindred factors woven into the context of present life all discourage the virtue of individual thinking at its foundations. Nor is our educational system blameless!

These observations are not true of more determined countries, such as Russia, where every encouragement, and even special inducements, are lavishly laid on. If democracy is to compete, immediate and serious attention is indicated.

There is no union for the forward-looking, but if every progressive designer and inventor belonged to their only obvious advocate, the Institute of Inventors, I am certain a radical change for the better would rapidly ensue. As long as the constructive-minded and far-sighted among us remain dispersed throughout the country without focal representation nothing of much substance will be done. There must be a central point of contact we all support, because unity creates power, faith and confidence. Given these, both talent and recognition of talent would re-emerge together. They would, you know!

J. R. C. Moore

Speciality Instruments,
Norwich.

Problem in Design No. 14

Sir,

I have just read your latest issue dated April 1961, and feel that I must comment on problem No. 14 (p. 217). I have not the necessary time available at present to draw up sketches, but as my comments on the subject are somewhat belated, I hope you will excuse this shortcoming. If your interest was such I could produce a sketch in the near future.

Referring to the particular problem, I believe that it would be possible to use equipment similar in layout to a normal Froude dynamometer, but with the impeller replaced by a large disc, which could be of composite construction to allow internal water cooling via a double quill feed and return about the axis of the shaft, and located at its rear end. To take the place of the normal gate casing would be a frame free to swing on trunnion bearings. Mounted upon the frame would be a number of proprietary caliper disc brake units loaded from a common master cylinder via flexible pipes and controlled by a simple servo mechanism or by hand. The reaction of the frame could be measured in a number of ways, the most convenient of which I suggest would be a strain gauge ring with appropriate ratiometer, etc., or a hydraulic load cell, either system being calibrated in lb. ft. units. With both of these methods the swing of the frame would be very small, which would facilitate the initial balance necessary in this type of equipment.

Considering the capacities of proprietary disc brakes, and on the data available to me at present, the maximum torque absorption of a single unit is approximately 2,100 lb. ft. This refers to road vehicle duties. If same were to operate on a much larger water-cooled disc as suggested, I feel the maximum absorption could be raised to double this figure, which would provide 4,200 lb. ft. per unit. It is conceivable that three such units equally spaced on the swinging frame would be sufficient. However, should my assumption be incorrect there would be room to mount up to sixteen units and still contain the equipment within relatively small overall dimensions. Finally, I would add that the ultimate design would be based upon some experimental data, and, as in most mechanisms, a compromise of commercial factors.

F. L. Morton

This would seem to be a most realistic and practical suggestion as to how 6 h.p. at 3 r.p.m. could be absorbed, the advantage being that disc brake units are readily available "off the shelf".—Editor.

F. Perkins Ltd.,
Peterborough.

Insulation of Windings

Sir,

The article in your April 1961 issue entitled "Insulation of Windings for Traction Machines—Part 3", by Mr. W. Duckett, makes a number of somewhat misleading statements, and in order to put the record straight we would like to comment on these.

The opening paragraphs give the impression that Class H insulating materials are new and untried. Mr. Duckett does not seem to be aware that many hundreds of silicone insulated traction motors have now been built in the United Kingdom and many of them have been operating satisfactorily for several years. He does not bother to point out that the experimental work carried out by London Transport Executive began in 1948 and their tests have now moved well past the "experimental stage". L.T.E. announced in April 1958 that, having had some ten years' experience in the use of silicone insulating materials for traction motors, they were "now proposing to specify their use on a fair proportion of traction motors being provided for new rolling stock". The implication that silicone insulating materials have not yet been widely used in the United Kingdom is further enhanced by the fact that the photographs used to illustrate the text are both of American-built machines, whereas Mr. Duckett could have obtained similar photographs without any difficulty from any leading British manufacturer of traction motors.

In the section on series-wound field coils, the author advocates the use of one of our products, Megasil 1400 Varnish; we must point out that this is a modified silicone varnish which we recommend only for Class F applications. In this same section the author advocates, if the coils are to be stored, wrapping them in a protective coating tape impregnated in "melted silicone grease"; we must point out that one of the principal features of silicone greases is that they will not melt under any circumstances.

P. T. Howard

Midland Silicones Ltd.,
68 Knightsbridge, London, S.W.1.

NEW ROTARY ENGINE

THE purely rotary internal combustion engine, in which there are no reciprocating masses, has interested inventors since the first petrol engine. Many ingenious designs have been suggested, most of which proved dismal practical failures. Among the latest more successful designs is a prototype of a new internal combustion engine being developed by William R. Selwood Ltd. This prototype has a capacity of 700 c.c. and has run successfully at 7,000 r.p.m. While it is as yet too early for a critical evaluation, it is possible that this design may well bridge the gap between the conventional reciprocating engine and the gas turbine, a gap into which the N.S.U. Wankel engine could also fit.

The new Selwood rotary engine, designed by a Mr. Hughes, has no connecting rods, crankshaft, flywheel, oil pump or sump; no cooling water jacket, pump or radiator; no separate distributor; and requires no flexible mountings to dampen vibration. The principle may be understood by referring to Fig. 1, which shows a cylinder block *B*, a periphery spigot *S*, and another cylinder block *C*, all rotating together at the same speed about a common axis *YY*. As can be seen the plane of the spigot is not normal to axis *YY*, but is inclined to the ends of the cylinder blocks.

Referring to points B_1, S_1 and C_1. it will be seen that as these rotate the distance between B_1 and S_1 decreases, while the distance between S_1 and C_1 increases, until at 180° of rotation from the original position, B_1 to S_1 will be a minimum and S_1 to C_1 will be a maximum. Further rotation will cause B_1 to S_1 to increase, and S_1 to C_1 to decrease, until after 360° of rotation from the original starting point the distances will have resumed their normal relationship.

Thus, by virtue of the cant of the spigot *S*, there is a relative axial motion between the spigot and the cylinder blocks, so that if pistons are fitted on each side of the spigot and located in cylinders in the blocks *B* and *C* (see Fig. 3), it is possible by a suitable arrangement of inlet and exhaust ports to obtain a two-stroke engine.

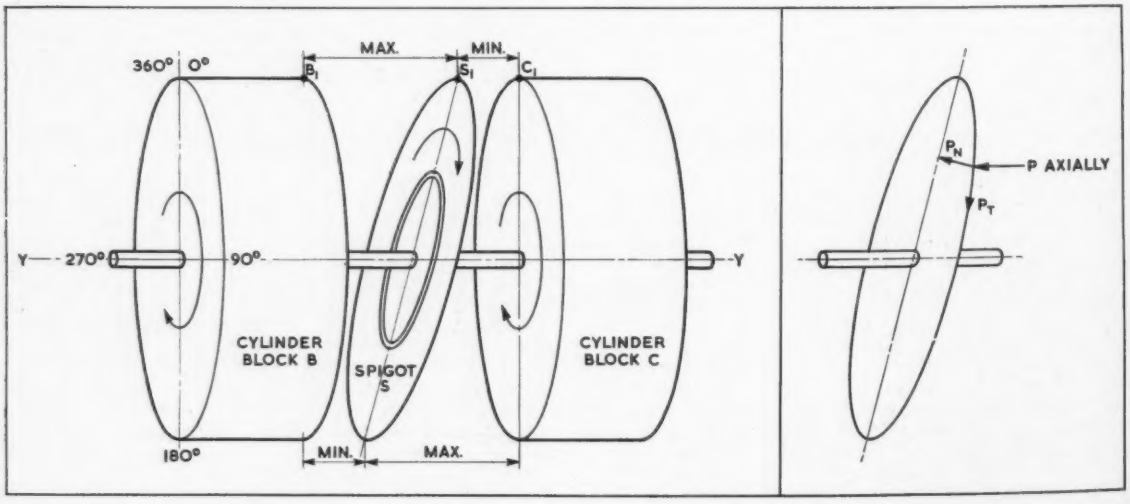
Normal two-stroke mixture is admitted down the central induction tract, and distributed evenly round the induction ports. Some of the mixture passes down the centre of the fixed shaft to lubricate the roller bearing on the outlet side before passing to the combustion chambers. The exhaust ports are arranged on the outside of the rotating mass.

The distribution of the charge is thus almost ideal. Ignition is by normal sparking plugs arranged in two banks. These pass near static electrodes, and as they do so a spark jumps across a small clearance between these electrodes and the tops of the plugs; thus the engine acts as its own distributor. Cooling is by forced convection from the surface of the rotating mass, which is finned normal to the axis of the fixed shaft. Fins in line with the shaft would be an improvement, but would be more difficult to produce.

Because the engine works on a two-stroke cycle, the exhaust gases have to be scavenged from the cylinder, and because the engine is double acting the usual method of using crankcase compression cannot be applied—a conventional Roots-type blower is therefore driven by the prototype engine.

Referring to Fig. 3, the piston in the cylinder at the top is at the right-hand end of the cylinder (in the position of S_1C_1 in Fig. 1), and is just about to fire. When it fires the gas must expand, and the only way it can do so is to push the piston to the left. To achieve this, the cylinder block assembly must rotate to the next position S_1C_1, and thus cause the engine drive shaft to rotate also, the position of the pistons moving relative to the cylinders. This is better understood, possibly, by considering the forces acting on the spigot disc during the firing (power) stroke. As shown in Fig. 1 (*right*), the axial force due to the explosion has two components: P_N normal to the plane of the spigot disc, and P_T tangential to the spigot disc. It is this latter force which supplies the turning moment about axis *YY* and provides the motive power.

Fig. 1. Diagrams illustrating the principle of operation of the new rotary engine.



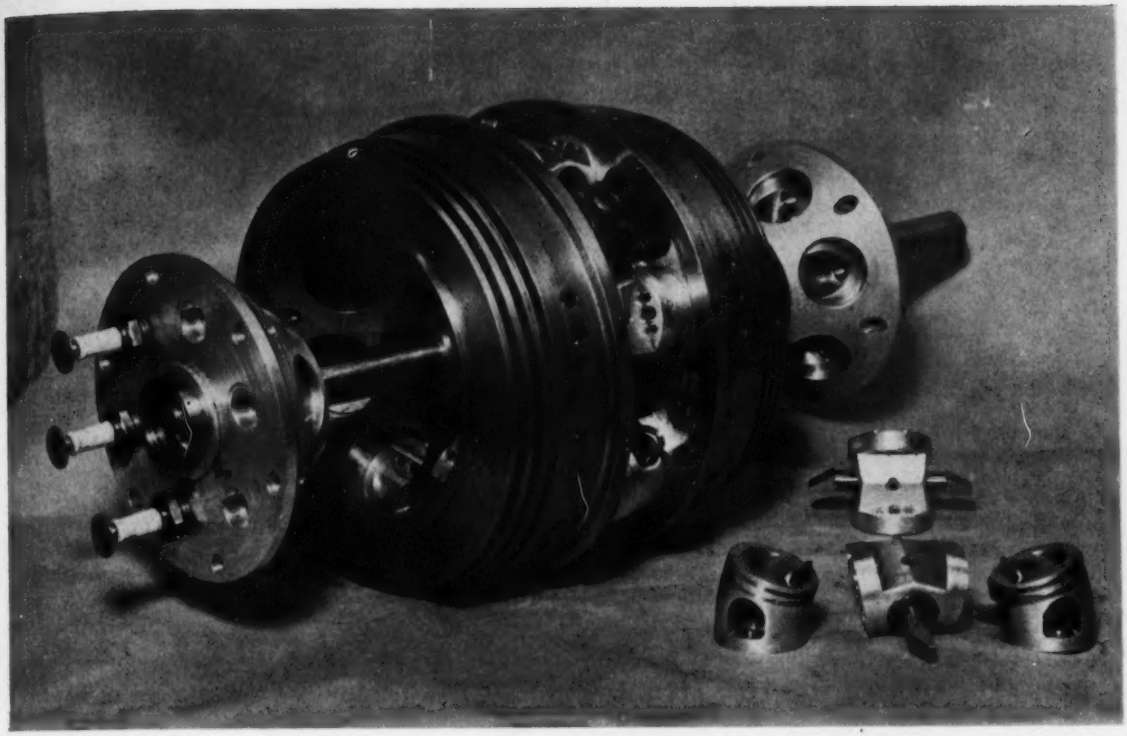
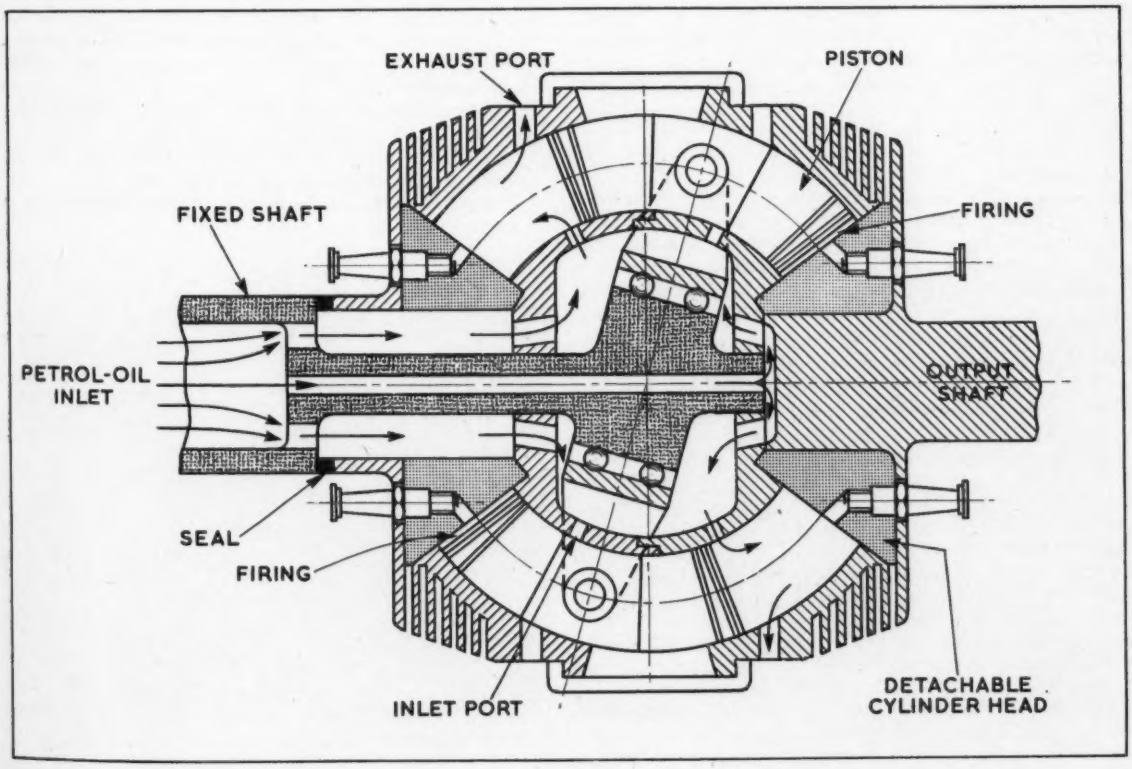


Fig. 2. Engine dismantled to show component parts.

Fig. 3. Diagram showing the basic assembly of the Selwood engine.



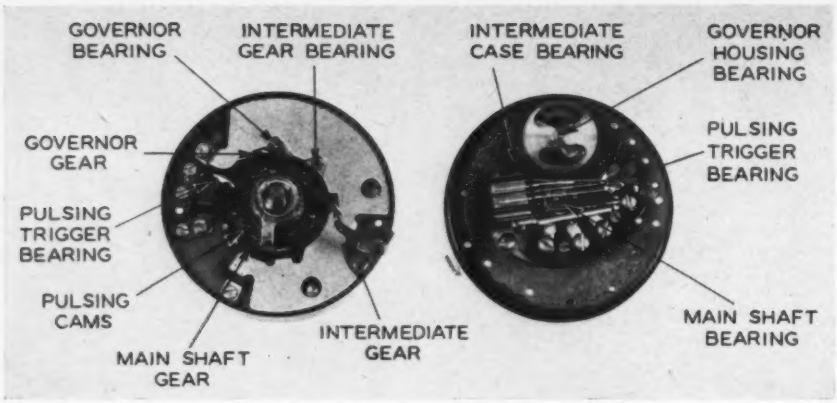


Fig. 1. Front and rear views of a standard pattern telephone dial, showing the points which require lubrication.

LUBRICATION OF SMALL APPARATUS

Lubrication is an important factor in many fields of industry, from heavy equipment to instrument parts. One of these fields is that of small apparatus, represented by telephone and electronic components, small motors, gear trains and timing devices

BY the development of specialised lubricants and lubrication practices, the life of small apparatus may be extended many-fold, and often the initial lubrication can be made sufficient for life. Or if relubrication is necessary during service life then the number of relubrications may be cut to a minimum, and the process of relubrication often made easier and more effective.

In order to specialise in lubrication, it is first of all necessary to become thoroughly familiar with the functioning of the apparatus and the service conditions encountered. This review should be followed by an analysis of all wear points and any trouble conditions encountered in the past. With such a background of information, the requirements can be set and measures taken to select and develop suitable lubricants.

To illustrate this a telephone dial has been chosen (see Fig. 1). This is a spring mechanism wound up by hand and released under the control of a governor to furnish electrical pulses for operating associated relays and switches. It has a central shaft; brass gears; brass, bronze and steel bearings; pulsing cams and a governor—altogether thirteen points to be lubricated. The tension of the spring is set and the governor adjusted to limit the speed to 10 ± 1 pulses per sec. at room temperature. Service conditions demand that the speed be controlled to these close limits. The dial is expected to operate for life without relubrication, under temperature conditions from 10-50 deg. C., in reasonably well-protected locations.

Examination of many dials which had mechanically failed indicated that worn-out gear teeth and bearings, particularly the teeth of the intermediate gear and its bearing, were the chief causes of wear failure. However, on preliminary tests it was found that if the bearing wear was reduced, the impact on the gear teeth from rotation reversal was considerably reduced, and wear of the gear teeth was practically eliminated. In the lubrication of a piece of apparatus such as this, containing many lubrication points, it is usually found that if the first few important points are taken care of, the same lubricant will be more than adequate for the rest of the points. In the case of the dial, the order in importance of the first few wear points is as follows: (a) intermediate gear bearings; (b) governor bearings; and (c) gears.

From a casual look at such a piece of apparatus without previous knowledge of the problems, most designers or engineers would recommend lubrication with an instrument or low-viscosity oil. A review of past trouble conditions encountered on dials which had been lubricated with an oil having a viscosity of approximately 40 centistokes at 38 deg. C. indicated the chief causes of trouble to be lack of lubricant, leakage of lubricant on to the governor braking surfaces, and rusting of the main bearing shaft.

With this background of information the functional requirements of the lubricant may be generalised as follows:

1. It must not materially change the speed of the dial throughout the operating temperature range.
2. It must be sufficiently fluid to flow freely into the bearings.

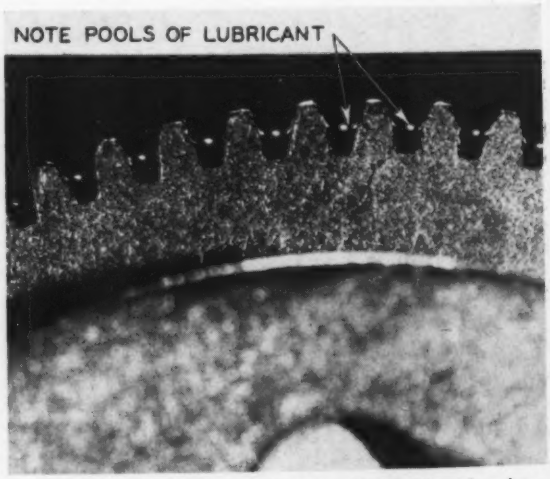


Fig. 2. Gear teeth lubricated with a semi-fluid product by means of a solvent dilution method.

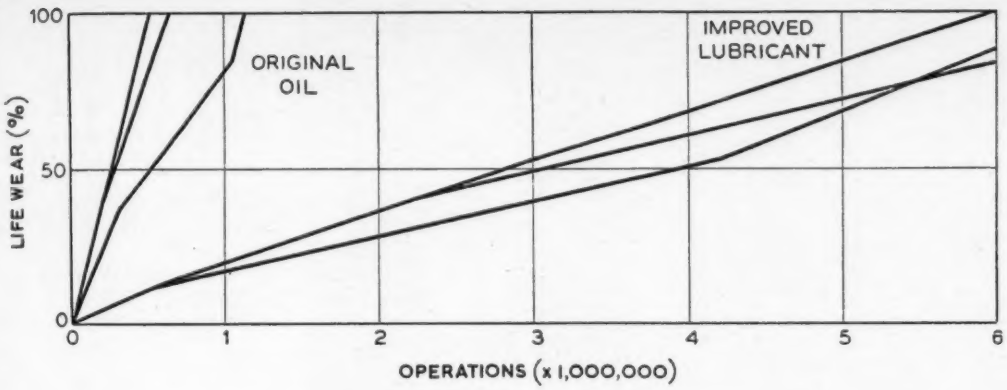


Fig. 3. Results obtained from wear tests, using two different lubricants.

3. It must not leave any gummy deposits.
4. It must protect against corrosion.
5. It must not creep on to the friction surfaces of the governor.
6. It must prevent wearing of the parts and provide the maximum life possible.
7. It must provide smoother operation and reduce noise.

The 40 centistoke oil used in the past fulfils the first three of the above requirements, but sadly fails to meet the other four. The lubricant found to be the most satisfactory was a semi-fluid product which was considerably more viscous, consisting of a base oil having a viscosity of approximately 240 centistokes at 38 deg. C., and 4 per cent calcium soap.

Although the type of lubricant to be used is important, its effectiveness is inseparably tied to how satisfactorily it can be applied in the right quantities to the places desired, and whether it will stay where intended.

Fig. 2 shows the lubricant applied to the intermediate gear by means of a solvent dilution process—note the reservoirs of lubricant between the gear teeth which feed oil gradually to the tooth surfaces. Due to the quantity applied and the location of this viscous lubricant, it has little effect on the dial speed. Fig. 4a shows the intermediate gear bearing of a dial after it had been lubricated with the original oil, and the dial operated 500,000 times—note the excessive wear. Fig. 4b shows the same gear bearing after lubrication with the more viscous semi-fluid product, and a dial operation of 1,000,000 times—the wear was negligible, and a pool of lubricant remained around the bearing. The application process consisted of applying a carefully controlled quantity of the lubricant to the bearing with a special tool which could be used on the assembly line. After a few operations of the dial a part of the lubricant worked its way down into the bearing, and the remaining lubricant served as a reservoir to continually replenish it. The viscous semi-fluid product had little effect on the speed of the dial because of the method of application to the gears and the small amount of the total torque absorbed by the bearings. This is an excellent example for demonstrating the four Rs of good lubrication practice: the right lubricant, the right quantity, in the right place, at the right time—each one can be of major importance.

Fig. 3 shows the results of dial life tests using the two different lubricants. Dials lubricated with the original oil performed satisfactorily for approximately 500,000 operations, while dials lubricated with the improved lubricant had their life increased approximately ten-fold. Also, with the improved lubricant the dials operated more smoothly, and from 2 to 5 decibels quieter.

These savings may be unusual, but the technique of developing the right lubricant to suit the apparatus and its conditions, and of recognising the extreme importance of the other three Rs of lubrication, can be applied to many other things with surprising success.

From a paper by F. Hardy, of Bell Telephone Laboratories Inc., published in *Lubrication Engineering* (A.S.L.E. journal).

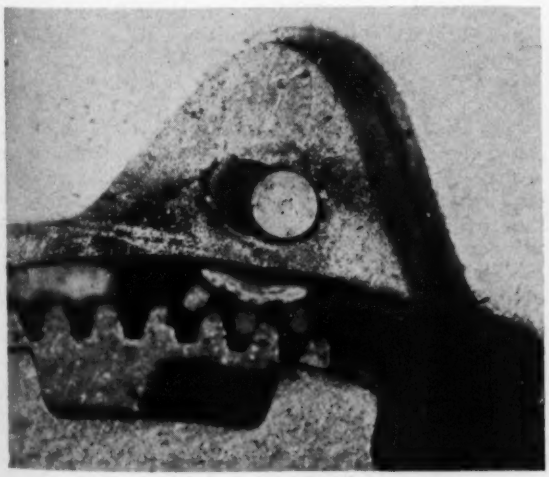


Fig. 4a. Original oil after 500,000 operations.

Fig. 4b. Viscous semi-fluid lubricant after 1,000,000 operations.

Mr. Krushchev visiting the English Electric stand, accompanied by Mr. L. H. Short, the firm's director of overseas operations. Behind Mr. Krushchev is Mr. R. B. Coulson, of the English Electric Valve Co. Ltd., with next to him Mr. R. Maudling, President of the Board of Trade.

SUCCESSFUL BRITISH TRADE FAIR IN MOSCOW

Well over a million Russian visitors attended the 1961 Moscow Fair, which was a tremendous feat of organisation, in particular by Mr. V. G. Sherren, managing director of Industrial & Trade Fairs Ltd.

THE Soviet Minister of Foreign Trade, Mr. Patolichev, in his speech at the opening ceremony, expressed his satisfaction and pleasure at the British Trade Fair, and commented: "This is indeed a good Fair; its wide scope does justice to the achievements of British people in the field of industry, science and technical equipment."

Mr. Patolichev also praised the high quality of British products, and said that this suited the Russians: "As we say in Russia, 'we are not so rich as to be able to buy cheap things'." Mr. Krushchev interrupted Mr. Patolichev to say that this was actually an English saying, and the Soviet trade minister replied that if it was a good one there was no harm in the Russians taking it over. Mr. Patolichev went on to say that the Soviet Union and Britain had great opportunities for developing trade between each other, and that the Soviet Union had many things to sell to Britain.

Following the opening speeches, Mr. Krushchev addressed the gathering on the need to make trade a two-way affair. He echoed Mr. Patolichev's words that the Soviet Union had many things to sell to Britain—in particular, said Mr. Krushchev, he hoped that Britain would buy Soviet oil. At the moment, he declared, Britain was buying oil from countries which bought nothing from Britain. He also maintained that British goods were sometimes expensive, and added that, though it was not up to him to teach British business men how to trade, he thought that it was best never to skin your trade partner entirely. One should always leave a little skin so that it could grow and one could skin him again. Mr. Krushchev concluded by again emphasising the importance he attached to trade exchanges between Britain and the Soviet Union.

Moscow Fair a Great Success

The Coventry Gauge & Tool Co. Ltd. announced the signing of a contract for the supply of £24,000 worth of jig and gear grinding machines.

* * *

J. K. Smith & Sons (Diamond Tools) Ltd. reported that Machinoimport purchased all the diamond bits on show, which were worth more than £5,000. A further contract for a complete range of diamond bits valued at over £10,000 was also discussed by the director of an oilfield.

The materials handling exhibits on the **Ludlow & Fisher** stand drew many inquiries from Russian engineers, and there were many compliments on the quality and effectiveness of the conveyor systems on show. Inquiries were received by delegates from Roumania, Poland and Hungary.

* * *

Hawker Siddeley Industries Ltd. announced that forty-nine National/Brush diesel generator sets were currently being delivered to the Soviet Union under a £575,000 order. The sets will provide electrical power for some of the remote rural areas of the U.S.S.R. which are not served by the Soviet national grid system.

* * *

The Steel Company of Wales has landed an order for 10,000 tons of sheet steel for the Soviet motor industry; it is understood that this will be used mainly for lorries.

* * *

The **Bendix** section, with its working launderette, attracted huge crowds, all interested as one bystander observed, in "anything that makes a woman's work lighter".

* * *

The Pressed Steel Co. stand, showing exhibits from their car body, refrigeration and aircraft divisions, reported an impressive number of inquiries from Soviet trade and other organisations. Marked interest was shown in the combination freight vehicle Roadrailer, which was described by the deputy director of Machinoimport as "this wonderful vehicle". The Pressed Steel staff were impressed by the high technical level of questions put by the general public and by trade experts.

* * *

Great interest was shown in an A40 and a Mini-Minor which were parked outside the Exhibition Hall. These **B.M.C.** cars covered the 6,000 miles through France, Belgium, Holland, West and East Germany, and Poland to Moscow in six days, doing the last 600 miles from Minsk in one day.

EMD 6913 for further information

Right from the drawing board stage

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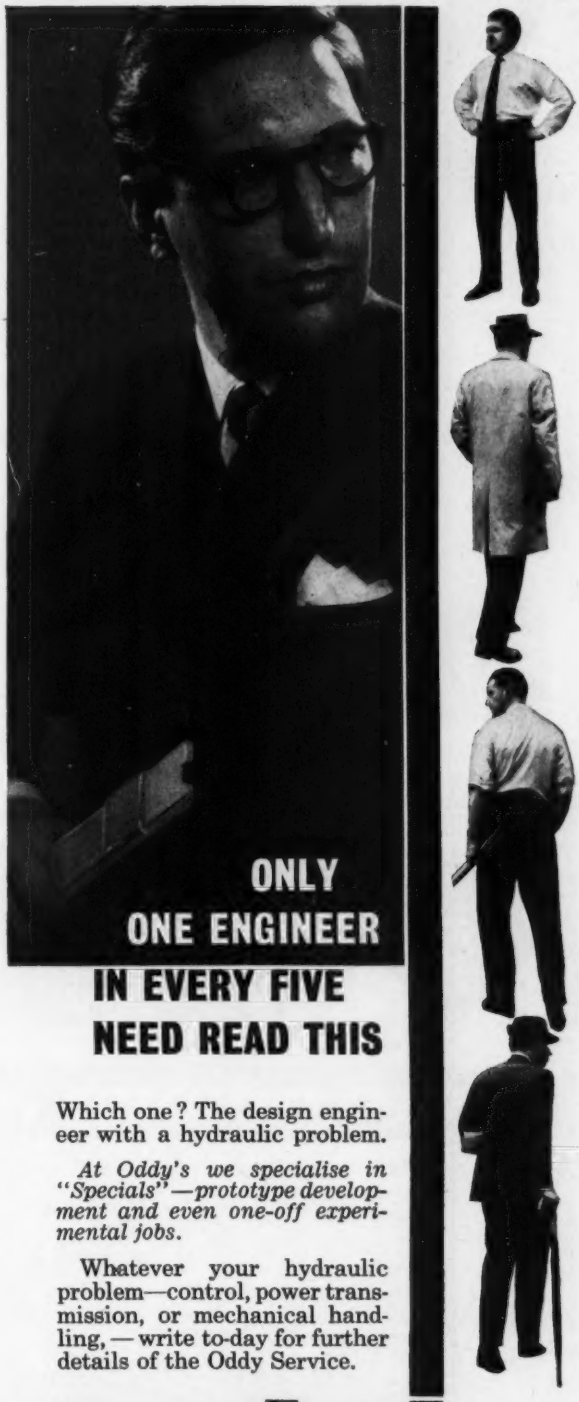

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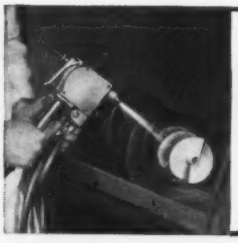

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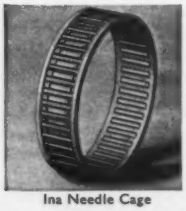
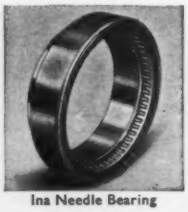

Ina Needle Cage


Ina Needle Bearing

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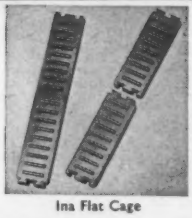
Ina Combined Bearing (NKIB Series)

Ina Thrust Bearing

CAGE GUIDED NEEDLE BEARINGS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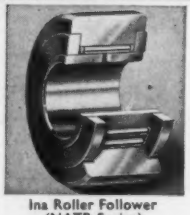
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NEW IDEAS IN DESIGN

Outstanding products in current manufacture and awaiting development in the U.K.

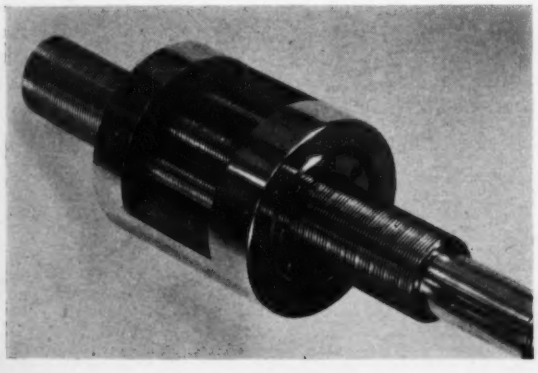
A Novel Anti-friction Screw without Backlash

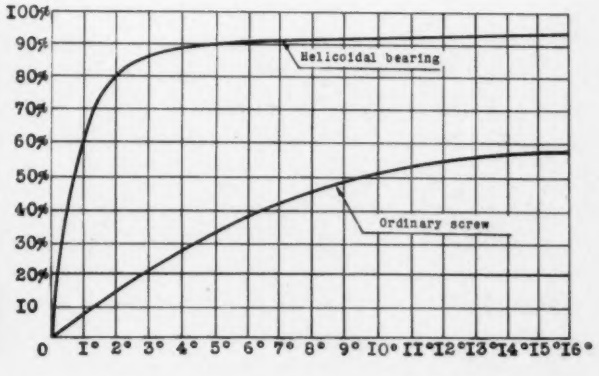
THE T.I. Helicoidal Bearing, a product of La Technique Intégrale, of Paris, enables rotary movement to be converted into linear movement with, it is said, the almost total suppression of sliding friction. Efficiencies between 70 and 95 per cent are claimed.

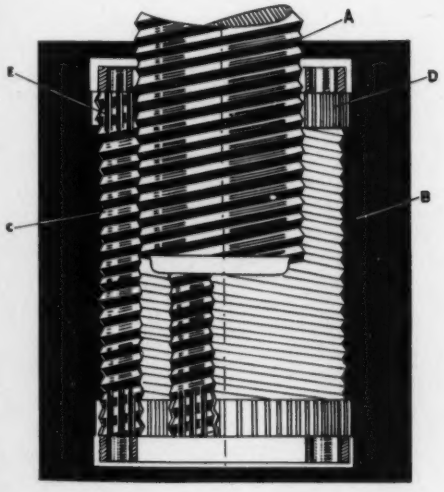
The bearing is composed essentially of three parts: a screw *A*; a socket *B*, concentric with the screw but having an internal diameter greater than the diameter of the screw; and a certain number of threaded rollers *C* interposed between the screw and the socket.

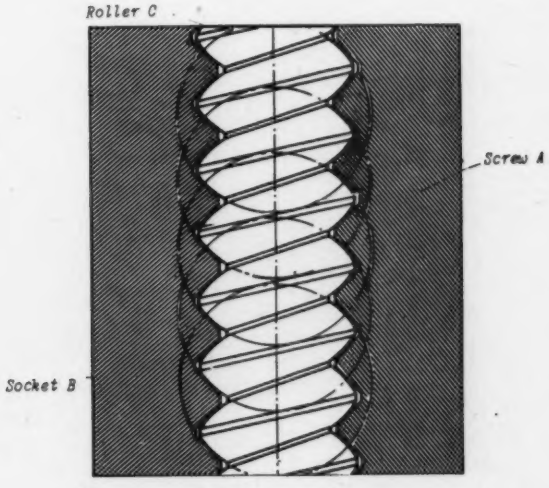
The unit is so designed that no longitudinal displacement of the rollers can take place with respect to the socket. The threads of the rollers and those of the socket which are engaged have, in fact, the same width and the same pitch. Under these conditions, a pure rolling effect is obtained on the pitch cylinders. The section of the thread has the shape of a curvilinear triangle, with the object of localising the bearing surface. The rollers roll in the socket like rollers in a bearing having a helicoidal shape. The need to allow a certain working play results in the fact that the rolling conditions, along the pitch diameters, are not obtained perfectly in spite of the precision of manufacture. In order to prevent slip therefore, the effect of which would be a longitudinal displacement of the rollers with respect to the socket, the engaging teeth *D* and *E* form extensions of the extremities of the threads of the socket and of the roller threads, thus ensuring the intended theoretical speed of rotation. The rollers, which have a special profile, also move along the screw by rotating about this latter in a complex movement of rolling with a very slight slip. High efficiencies are thus obtained. The accompanying graph compares the efficiency of the helicoidal bearing with that of the standard types of screw-nut unit, as a function of the angle of slope of the screw-threads (this angle is such that $Tg\ a = \frac{P}{\pi D1}$, P being the resultant pitch and $D1$ the pitch diameter of the screw).

The photograph shows one variant of the T.I. helicoidal bearing nut, which is available in a variety of forms for different applications. These include the operation of flight controls in aircraft, the movement of machine-tool tables, and the operation of gate valves, mechanical jacks, servo-mechanisms, etc. A special form of the helicoidal bearing, with sockets in two parts for taking up play, is now used on certain French machine tools, notably in milling machines. This form of backlash-free device enables climb milling to be carried out.







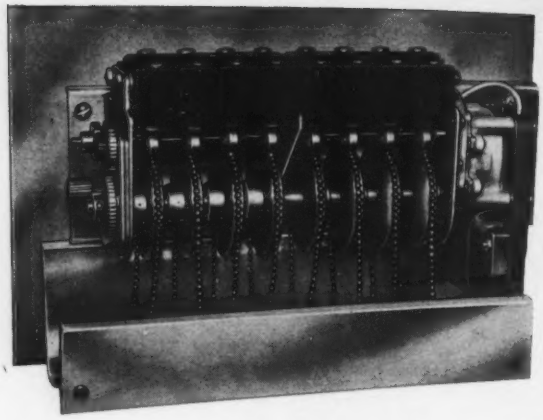


New Timer uses Beaded Chain

AN interesting application of bead chain, in the new Eagle timer recently introduced by Davis Automatic Controls Ltd., of Toronto, makes possible the simple solution of many complex sequencing problems. The essential feature of the synchronous motor-driven timer, the cam, has been removed and replaced with a drive sprocket which serves to advance an endless steel bead chain.

To establish the cam action, which actuates the switch at the desired time, large beads are fitted to the chain. The beads may be fitted singly, to give a momentary closure, or in groups to produce a sustained closure. Vari-coloured beads are used for coding.

The timer is fitted with from two to twelve switches, and can be used for multiple circuits, with microsecond timing.



Parallel Link Rubber Springing System

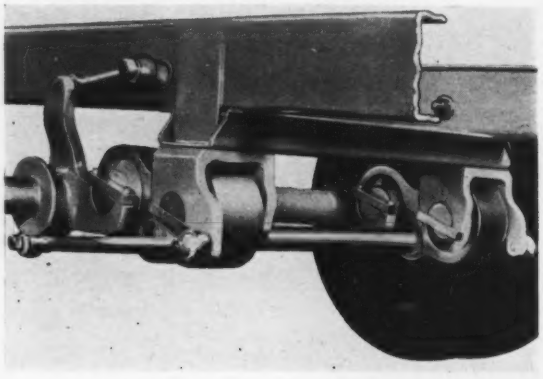
A NEW type of rubber springing made by Metalastik Ltd. is said to be suitable for the front and rear axles of trucks, buses, trailers and semi-trailers. It has been arranged to fit in conveniently with comparatively narrow and high chassis frames without the addition of any considerable amount of extra structure, and is claimed to provide the change of stiffness with loading which is desirable for good riding, both laden and unladen.

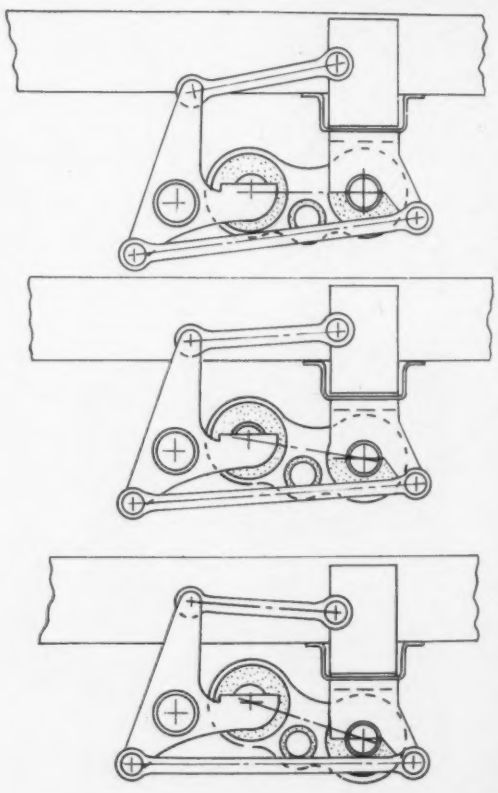
Three positions of the suspension assembly are illustrated in the accompanying diagram. In the first position the centre link, which carries the large torsion bushes forming the sole means of springing, is horizontal and slightly compressed, putting both the control links in tension. In this position the suspension carries the tare weight of the vehicle. The spring stiffness due to the torsion of the large bushes, increased slightly by the torsion of the top and bottom link bushes, is partially counter-balanced by the negative stiffness due to compression of the centre link.

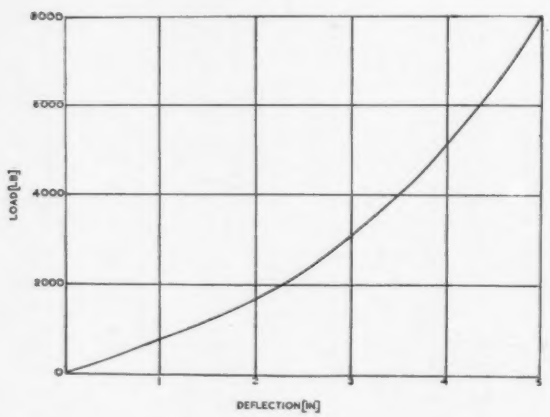
In the second position the centre or torsion link is inclined to the two control links, and its bushes are concentric and therefore loaded in torsion only. The stiffness of the suspension is due almost entirely to rubber in torsion.

In the third position the link is more inclined, and is extended against the radial resistance of the bushes. This radial resistance gives a further stiffness to the spring, which increases rapidly with over-travel.

The type of load-deflection provided is shown in the graph, while the photograph illustrates the typical proportions of a chassis for a truck of about 7 tons capacity, the construction being equally adaptable for a live rear or front axle, or to trailer axles.







OVERSEAS NEWSLETTER

A monthly digest of reports from our foreign correspondents of other countries' current achievements in research and development work

Sprayed Bearing Materials

It is reported that experiments are being carried out in the heavy engineering industries of the U.S.S.R. on bearings formed by a metallising process, with a view to replacing the more expensive existing bronzes and white metal linings. Spraying anti-friction alloys enables bi-metal inserts and bushings to be easily manufactured; these combinations have the capacity to absorb lubricants.

The alloys tested included Al-Fe; Fe-Cu; Fe-Cu-Zn; Fe; Cu-Sn; and Cu-Sn-Pb combinations — each alloy was deposited on a steel and copper foundation. Except for the steel deposit, the average coefficient of friction for the alloys was about 0·1 with limited lubrication, and 0·006 with copious lubrication. The 50 per cent Al- 50 per cent Fe bearing proved to be the best with regard to seizure resistance, while the greatest load-carrying capability was exhibited by the heat-treated copper-tin coatings. It was concluded that the possibility clearly exists for the replacement of bronze and babbitt bearings by these cheaper sprayed coatings, without the lessening of wear or load-carrying properties.

Stainless Steel Silencer

The Ford Motor Co. of the U.S.A. has introduced, on the Thunderbird car, a new silencer, more than 50 per cent of which is made from stainless steel. The new MF-1 steel for the improved silencer, developed by Allegheny Ludlum Steel Corp., is estimated to be from five to six times more corrosion-resistant than aluminised steel, and from fifteen to eighteen times more corrosion-resistant than the conventional mild steel used in most of today's silencers.

The Thunderbird has a dual exhaust system which calls for two silencers, each of which weighs 13 lb., the amount of stainless steel used in making each silencer being 7 lb. The MF-1 material is used for the inner shell, one of the baffles and the heads of the muffler, these being the areas that are subjected to corrosive wear. The inner shell and baffle are of 0·036 gauge and the heads of 0·048 gauge. MF-1 has a chrome content of about 11 per cent with titanium and other elements added, and is unusually ductile and very easy to weld.

High-temperature Epoxy Resin

The Brunswick-Balke-Collender Co. in the United States report a new high-temperature epoxy resin which appears to overcome the disadvantages of unsatisfactory performance in the 260 deg. C. temperature range and the difficulties in filament winding techniques and moulding, using pressure or vacuum bags. The composition of the resin is not disclosed by the company, but a basic component is dicyclopentadiene, maleic anhydride being utilised as a curing agent.

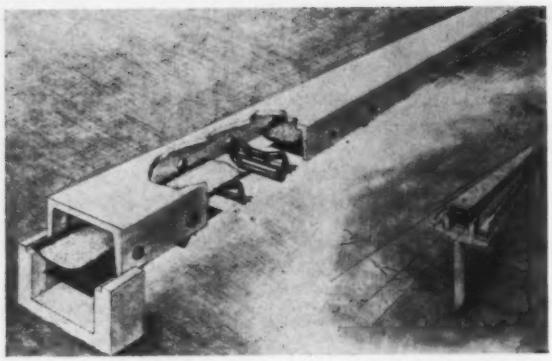
At a temperature of 260 deg. C. for a duration of 30 min., the tensile strength is given as 41,000 p.s.i., while the flexural modulus of elasticity is $3{\cdot}18 \times 10^6$ p.s.i. The new resin, designated VC-8359, was produced specifically for filament winding and low-pressure laminating processes, but initial work suggests that, with slight modification, the resin may be adaptable for potting or encapsulating purposes. Post-curing the resin at temperatures below 260 deg. C. produces a translucent material with excellent electrical properties at temperatures up to that of curing. The resin contains no solvents and can be cured relatively quickly, optimum strengths being obtained with moulding pressures of approximately 11 p.s.i.

Vehicle Identification System

To ensure greater safety on railways, Electronic Associates Ltd., of Canada, have devised a system which automatically indicates the position of every train, at all times, in relation to check points on the main line and sidings. It ensures that the entire length of a given train has entered a certain section, and identifies the train from the number on the leading locomotive. In addition, it shows the direction in which each train is travelling as it passes over the check point. Human errors by the operating personnel are said to be almost impossible.

The coupling between vehicle and trackside is in the form of radiation, affected only negligibly, it is claimed, by dust, dirt, grease, rain, snow or ice, or by mechanical shock. Nor is it affected by change in light, by temperature changes, or electrical interference. Since the vehicle apparatus and the track component must be in close proximity, no other nearby vehicle or even adjacent tracks can cause incorrect or confused information to be transmitted. Because no electronic components are used on the vehicle, and no power is required from it, reliability is said to be high, and vehicle equipment maintenance negligible.

The emitter, a small steel box, is mounted on the understructure of the last vehicle in the train, and radioactive materials placed in the box cause gamma rays to emerge from the bottom in a pattern individual to that vehicle. A gamma ray detection device is placed between the rails at each reading point. When an emitter crosses a detector it gives its individual signal, which is then converted into a form suitable for transmission by landline to a Data Centre, where a large display board contains a plan of the whole rail system with numbered detection points. Signals are decoded and sorted as they arrive, and then recorded on the appropriate numerical indicators.



New Conveyor System

The Calcoveyor, designed and patented by Frank J. Madison Co., of the U.S.A., is unique among conveyor systems because of its unit construction, and because the concrete channel serves both as protection for the material carried, and also as the main support for the belt drive and idlers. The basic inverted channel can accommodate all types of conventional idlers, and may also be designed to achieve any architectural effect required by its construction. On a recent installation 1½ miles long, a 36-in.-wide belt saved some 40 per cent on installation costs, and because of the simplicity of the design, the cost of maintenance is expected to be appreciably lower than with conventional systems.

Heat-treatment Simulation by Models

Russian metallurgists have developed methods for studying, by means of scale models, the deformation during heat-treatment of large and complex components. In many practical cases it is possible to obtain similarity at a substantially reduced scale by using a steel with a modified content of silicon.

It is stated that no similarity criteria have been formulated hitherto. On the basis of the theory of plasticity and relations expressing the structural transformations taking place in heat-treatment, a set of equations has been formulated supplemented by the boundary value problem of heat conductivity and transfer.

As a result of the analytical study, no fewer than fourteen non-dimensional parameters have been shown to be necessary in order to fully define the heat-treatment process. One of these parameters is the well-known Biot Number, which characterises the ratio of the internal resistance to heat flow to the resistance at the boundary of the body. Three of the parameters describe the metallurgical transformation by diffusion. Another three parameters describe the martensitic transformation. Five parameters define the mechanical problems, and two parameters describe the specific volume of the elements of grain structure.

The possibilities of model similarity depend on the particular transformations taking place. Generally, when cooling at an arbitrary rate in the presence of both diffusion and martensitic transformations, the scale model must be of a material different from that of the full-scale component. Simulation for steel components is possible by a scale model made of a steel with a different silicon or copper content.

The initial heat-treatment temperature and the temperature of the cooling medium must be the same for both the full-scale component and the scale model. Formulæ have been derived for selecting the dimensional scale and the properties of the cooling media. In one example, by increasing the silicon content of a 1% carbon steel from 0·3 to 1·3%, the dimensional scale becomes 2·5. In a large forging even this scale factor may be a valuable achievement, since the weight of the scale model obviously goes down with the third power of the scale.

In cases where only diffusion transformation takes place, the scale model must still be made of steel with a different composition. However, since the number of similarity criteria is smaller, many more changes in composition qualify.

In the case of through hardening when martensic transformation only takes place, the scale model can be of the same material as the full-scale component. If the temperatures of soaking and of the cooling medium are also identical, all criteria are fulfilled automatically, except the Biot Number. This number determines the nature of the cooling medium. The limits of the scale factor are determined only by the hardenability of the steel.

In heat-treatment processes wherein no structural transformations take place, the Biot Number alone remains to be fulfilled. In this instance, there are no limitations on the dimensional scale factor.

Foreign Briefs

Italian Plastics Roof

The new roof of the underground railway station Piazza Amendola, in Milan, is covered with contoured sheets of reinforced polyester plastics developed by Società Alpa, of Fiesco, Cremona. These sheets are supported largely by integrally moulded ribs which also act as a recurrent embellishing motif. Roofs of other buildings have been similarly constructed using sheets of different thicknesses and varying colours.

German Crane

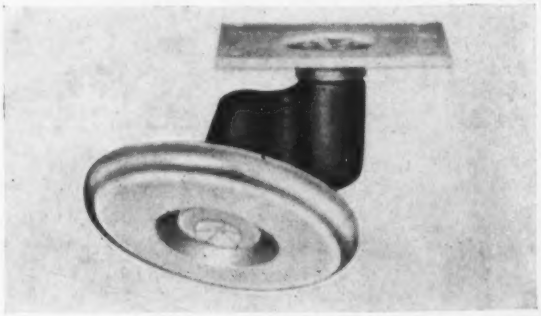
An interesting design feature of a recently installed Siemag overhead crane is internal tubular reinforcement of the main box girders. The lifting cables are also smaller in diameter than is usual, but are of equal strength—this enables smaller cable drums and rollers to be used.

Russian Lightweight Insulation

Obsidian, or volcanic glass, has been discovered in vast quantities in the Kamchatka peninsula, in the U.S.S.R., and work is being carried out to use this and similar materials such as perlite and ceramsite for building purposes. The foundation has already been laid for an experimental four-storey house to be constructed from obsidian. Obsidian swells when roasted in a kiln and becomes five times lighter than a similar volume of cork, yet still retains its hardness; mixed with cement, it forms an extremely lightweight heat-resisting concrete, which is being made into wall panels and blocks.

German Castors

The assembly shown in the accompanying illustration has a flat-faced wheel mounted at such an angle that, by varying the mounting angle, the face becomes a mounting pad. Produced by Fazit Gesellschaft für Transporttechnik mbh., it is particularly useful on collapsible fabric skips, which, when closed, can be stacked in a minimum of space.



STANDARD NUTS AND WASHERS FOR THREADS UP TO 1·0 IN. DIA.

(see page 385, June issue)

Engineering Materials and Design

DATA SHEET No. 63

NUTS WITH BA THREADS TO BS 93

	0	1	2	3	4	5	6	8	10	12	14	16	Specification
A			0·324		0·248		0·193	0·152	0·117	0·090			A 24, A 27 (2, 4 and 6 BA only), A 29 (2 and 4 BA only), A 47 to A 54 inclusive
E			0·370		0·290		0·220	0·180	0·140	0·100			
B*			0·167		0·135		0·105	0·082	0·064	0·049			
B†			0·123		0·094		0·073	0·058	—	—			
B‡			0·25		—		—	—	—	—			
P			$\frac{1}{16}$		—		—	—	—	—			
Drill No.			50		—		—	—	—	—			

* Ordinary nuts. † Thin or lock nuts. ‡ Slotted nuts.

A	0·5	0·437	0·375	0·312	0·312	0·25	0·25						BS 2827
E*	0·707	0·619	0·53	0·442	0·442	0·353	0·353						
E†	0·577	0·505	0·433	0·361	0·361	0·289	0·289						
B	0·128	0·128	0·106	0·095	0·095	0·082	0·082						

* Square nuts. † Hexagon nuts.

A	0·413	0·365	0·324	0·282	0·248	0·22	0·193	0·152	0·117	0·09	0·069	0·056	BS 57, BS 1083 (2 BA only)
E	0·48	0·42	0·37	0·33	0·29	0·25	0·22	0·18	0·14	0·10	0·08	0·07	
B*	0·213	0·188	0·167	0·153	0·135	0·120	0·105	0·082	0·064	0·049	0·037	0·029	
B†	0·157	0·139	0·123	0·108	0·094	0·084	0·073	0·058	—	—	—	—	

* Ordinary nuts. † Thin or lock nuts.

WING NUTS

A*	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{13}{16}$	$\frac{13}{16}$	$\frac{11}{16}$	$\frac{11}{16}$							BS 856
E*	$1\frac{3}{16}$	$1\frac{3}{16}$	1·0	1·0	$\frac{7}{8}$	$\frac{7}{8}$							
D*	$\frac{5}{8}$	$\frac{5}{8}$	$\frac{5}{8}$	$\frac{5}{8}$	$\frac{5}{8}$	$\frac{5}{8}$							
A†	$\frac{31}{64}$	$\frac{31}{64}$	$\frac{27}{64}$	$\frac{27}{64}$	$\frac{11}{16}$	$\frac{11}{16}$							
E†	$1\frac{3}{16}$	$1\frac{3}{16}$	$\frac{21}{32}$	$\frac{21}{32}$	$\frac{21}{32}$	$\frac{21}{32}$							
D†	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{7}{16}$	$\frac{7}{16}$	$\frac{1}{2}$	$\frac{1}{2}$							

* Cast or hot forged. † Cold stamped.

NUTS WITH BSF AND BSW THREADS TO BS 84

	$\frac{1}{32}$	$\frac{3}{32}$	$\frac{1}{8}$	$\frac{5}{32}$	$\frac{3}{16}$	$\frac{7}{32}$	$\frac{1}{4}$	$\frac{5}{16}$	$\frac{3}{8}$	$\frac{7}{16}$	$\frac{1}{2}$	$\frac{9}{16}$	$\frac{5}{8}$	$\frac{3}{4}$	$\frac{7}{8}$	1·0	Specification
T.p.i.		48	40	32	24 and 32	24 and 28	20 and 26	18 and 22	16 and 20	14 and 18	12 and 16	12 and 16	11 and 14	10 and 12	9 and 11	8 and 10	
A		0·25	0·25	0·312	0·375	0·437	0·5	0·562	0·625								BS 2827
E*		0·353	0·353	0·442	0·53	0·619	0·707	0·795	0·884								
E†		0·289	0·289	0·361	0·433	0·505	0·577	0·649	0·722								
B		0·082	0·082	0·095	0·106	0·128	0·128	0·160	0·179								

* Square nuts. † Hexagon nuts.

A	0·117	0·152	0·22	0·248	0·324	0·413											BS 450
E	0·135	0·175	0·254	0·286	0·374	0·477											
B*	0·061	0·079	0·115	0·130	0·162	0·195											
B†	—	0·055	0·079	0·089	0·118	0·128											

* Ordinary nuts. † Thin or lock nuts.

A							0·445	0·525	0·60	0·71	0·82	0·92	1·01	1·2	1·3	1·48	BS 916
E*							0·51	0·61	0·69	0·82	0·95	1·06	1·17	1·39	1·5	1·71	
E†							0·63	0·74	0·85	1·0	1·16	1·30	1·43	1·7	1·84	2·09	
B‡							0·22	0·27	0·332	0·395	0·467	0·530	0·602	0·728	0·810	0·935	
B§							0·20	0·25	0·312	0·375	0·437	0·50	0·562	0·687	0·75	0·875	
B ‖							0·185	0·21	0·26	0·275	0·3	0·333	0·410	0·49	0·55	0·63	
B††							—	—	—	—	—	—	0·375	0·458	0·50	0·583	

*Hexagon nuts. † Square nuts. ‡ Black ordinary nuts. § Black faced nuts. ‖ Black thin or lock nuts. †† Faced thin or lock nuts.

A							0·445	0·525	0·60	0·71	0·82	0·92	1·01	1·2	1·3	1·48	BS 1083
E							0·51	0·61	0·69	0·82	0·95	1·06	1·17	1·39	1·5	1·71	
B*							0·2	0·25	0·312	0·375	0·437	0·50	0·562	0·687	0·75	0·875	
B†							0·133	0·166	0·208	0·25	0·291	0·333	0·375	0·458	0·5	0·583	

*Ordinary nuts. † Thin or lock nuts.

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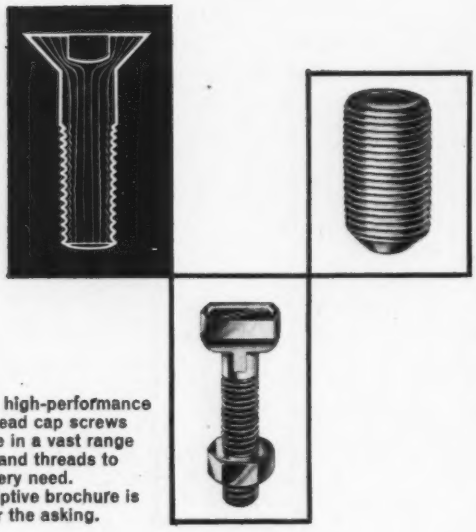

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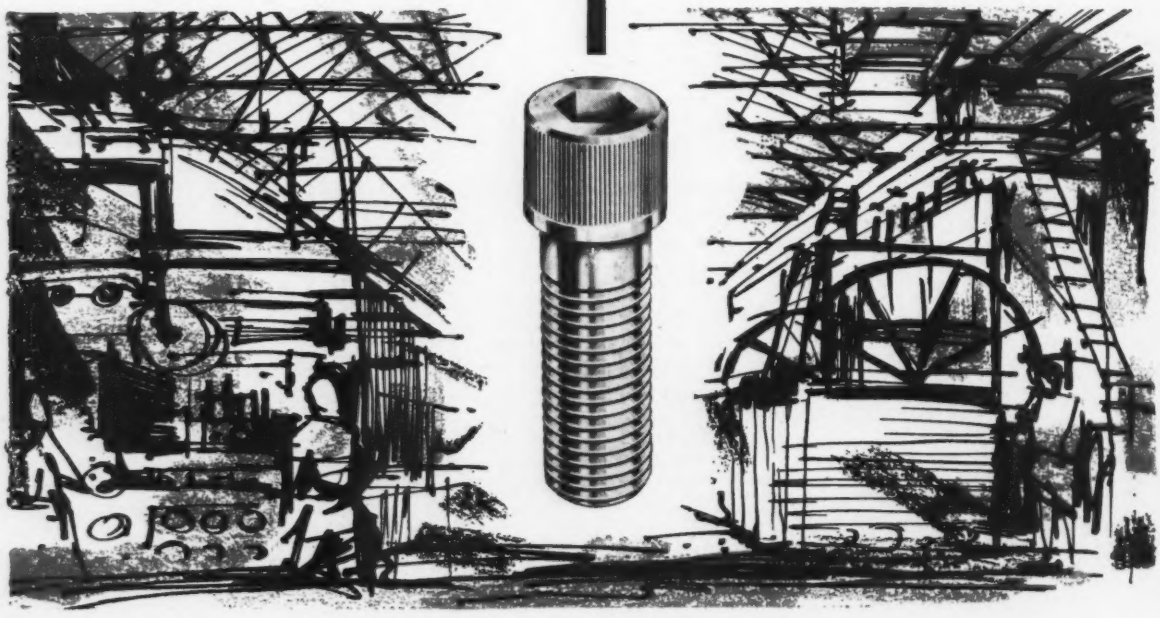

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NUTS WITH BSF AND BSW THREADS TO BS 84 (cont.)

	1/16	3/32	1/8	5/32	3/16	7/32	1/4	5/16	3/8	7/16	1/2	9/16	5/8	3/4	7/8	1·0	Specification
T.p.i.		48	40	32	24 and 32	24 and 28	20 and 26	18 and 22	16 and 20	14 and 18	12 and 16	12 and 16	11 and 14	10 and 12	9 and 11	8 and 12	
A							0·445	0·525	0·60	0·71	0·82	—	1·01	1·2	1·3	1·48	BS 325 (BSW threads only)
E*							0·51	0·61	0·69	0·82	0·95	—	1·17	1·39	1·5	1·71	
E†							0·63	0·74	0·85	1·0	1·16	—	1·43	1·7	1·84	2·09	
B							0·22	0·27	0·33	0·39	0·46	—	0·60	0·72	0·81	0·93	

* *Hexagon nuts.* † *Square nuts.*

A							0·445	0·525	0·60	0·71	0·82	0·92	1·01	1·2	1·3	1·48	A 24, A 27, A 29 (1/2 to 5/8 in. BSF)
E							0·510	0·61	0·69	0·82	0·95	1·06	1·17	1·39	1·5	1·71	
B*							0·20	0·25	0·312	0·375	0·437	0·50	0·562	0·687	0·75	0·875	
B†							0·133	0·166	0·208	0·250	0·291	0·333	0·375	0·458	0·50	0·583	A 58S (1/4 to 1/2 in. BSF)
B‡							0·26	0·28	0·312	0·375	0·437	0·50	0·562	0·687	0·75	0·875	
B§							0·20	0·20	0·20	0·20	0·20	—	—	—	—	—	A 58T (5/16 to 1/2 in. BSF)
B‖							0·29	0·34	0·402	0·515	0·577	0·687	0·749	0·921	0·984	1·155	
P							1/16	1/16	1/16	3/32	3/32	1/8	1/8	5/32	5/32	3/16	BS 1083 (BSF and BSW slotted and castle nuts only)
Drill No.							50	50	50	37	37	29	29	19	19	8	

* *Ordinary nuts.* † *Thin or lock nuts.* ‡ *Slotted nuts.* § *Plain and slotted shear nuts.* ‖ *Castle nuts.*

A							0·445	0·525	0·60	0·71	0·82	0·92	—	—	1·3	—	A 14
E							0·51	0·61	0·69	0·82	0·95	1·06	—	—	1·5	—	
B							0·13	0·15	0·16	0·18	0·20	0·20	—	—	0·3	—	

WING NUTS

	1/8	5/32	3/16	7/32	1/4	5/16	3/8	7/16	1/2	9/16	5/8	3/4	7/8	1·0	Specification
T.p.i.	40	32	24 and 32	24 and 28	20 and 26	18 and 22	16 and 20	14 and 18	12 and 16	12 and 16	11 and 14	10 and 12	9 and 11	8 and 10	
A*	1 1/32	—	1 3/32	—	1 1/2	1 5/8	1 1/16	2 3/4	2 7/8	—	1·0	1 1/4	—	—	BS 856
A†	1 5/16	—	2 7/64	—	3 1/4	1 5/8	1 3/4	2 3/8	2 7/8	—	1 5/32	1 5/32	—	—	
E*	7/8	—	1·0	—	1 1/16	1 1/4	1 1/2	2·0	2 5/16	—	2 1/2	3 1/16	—	—	
E†	1 1/32	—	2 7/32	—	1 1/16	1 1/16	1 3/32	1 7/8	1 7/8	—	2 11/16	2 11/16	—	—	
D*	1 7/32	—	1 9/32	—	2 3/32	2 3/32	1·0	1 1/4	1 1/2	—	1 7/16	1 1/8	—	—	
D†	1 1/32	—	7/16	—	1/2	5/8	1 3/32	2 9/32	2 9/32	—	1 3/8	1 3/8	—	—	

* *Cast or hot forged.* † *Cold stamped.*

NUTS WITH UNIFIED THREADS (UNC AND UNF) TO BS 1580

	1/4	5/16	3/8	7/16	1/2	9/16	5/8	3/4	7/8	1·0	Specification
A	0·437	0·5	0·562	0·687	0·75	0·875	0·937	1·125	1·312	1·5	BS 2708
E	0·505	0·577	0·65	0·794	0·866	1·01	1·083	1·30	1·515	1·732	
B*	0·226	0·273	0·337	0·385	0·448	—	0·559	0·665	0·776	0·887	
B†	0·226	0·273	0·337	0·385	0·448	—	0·559	0·644	0·754	0·871	
B‡	0·163	0·195	0·227	0·260	0·323	—	0·387	0·446	0·510	0·575	
B§	0·163	0·195	0·227	0·260	0·323	—	0·387	0·414	0·478	0·539	

* *Ordinary black nuts.* † *Ordinary, faced one side.* ‡ *Thin or lock nut, black.* § *Thin or lock nut, faced both sides.*

A	0·437	0·5	0·562	0·687	0·75	0·875	0·937	1·125	1·312	1·5	BS 1768
E	0·505	0·577	0·65	0·794	0·866	1·01	1·083	1·3	1·515	1·732	
B*	0·226	0·273	0·337	0·385	0·448	0·49	0·559	0·665	0·776	0·887	
B†	0·163	0·195	0·227	0·260	0·323	0·35	0·387	0·446	0·510	0·575	
B‡	0·28	0·33	0·41	0·46	0·57	0·62	0·73	0·82	0·92	1·01	
P	5/64	5/64	5/64	3/32	3/32	5/32	5/32	3/16	3/16	7/32	
Drill Size	8/32	8/32	8/32	7/64	7/64	11/64	11/64	13/64	13/64	15/64	

* *Ordinary nuts.* † *Thin or lock nuts.* ‡ *Thick slotted nuts.*

A	0·5	0·563	0·688	0·75	0·875	—	1·062	1·25	1·437	1·625	BS 3139 (1/2 to 1 in., ordinary faced one side) BS 1769 (1/2 to 1 in. only, ordinary, thin and slotted nuts) BS 2708 (1/4 to 1 in., ordinary and thin)
E	0·577	0·65	0·794	0·866	1·01	—	1·23	1·44	1·66	1·88	
B*	0·266	0·33	0·393	0·456	0·52	—	0·647	0·774	0·901	1·028	
B†	0·25	0·314	0·377	0·441	0·504	—	0·631	0·758	0·885	1·012	
B‡	0·204	0·236	0·268	0·30	0·332	—	0·397	0·462	0·526	0·590	
B§	0·188	0·220	0·252	0·285	0·317	—	0·381	0·446	0·510	0·575	
P	—	—	—	—	1/8	—	5/32	5/32	5/32	7/32	
Drill No.	—	—	—	—	9/64	—	11/64	13/64	13/64	15/64	

* *Ordinary, as forged.* † *Ordinary, faced one side.* ‡ *Thin or lock nut, as forged.* § *Thin or lock nut, faced both sides.*

NUTS WITH UNIFIED THREADS (UNC AND UNF) TO BS 1580 (cont.)

	UNC			UNF											
	4/40	6/32	8/32	10/32	1/4	5/16	3/8	7/16	1/2	9/16	5/8	3/4	7/8	1·0	Specification
A	0·188	0·25	0·312	0·344	0·433	0·50	0·562	0·688	0·75	0·875	0·938	1·062	1·25	1·438	A 103, 105, 107 and 110. A 210 (4/40 to 10/32)
E	0·217	0·289	0·361	0·397	0·505	0·577	0·65	0·794	0·866	1·01	1·083	1·227	1·443	1·66	
B*	0·105	0·125	0·155	0·167	0·20	0·25	0·312	0·375	0·437	0·50	0·562	0·687	0·75	0·875	
B†	0·073	0·089	0·113	0·123	0·133	0·166	0·208	0·250	0·291	0·333	0·375	0·458	0·50	0·583	
B‡				0·25	0·26	0·28	0·312	0·375	0·437	0·50	0·562	0·687	0·75	0·875	
B§				—	0·20	0·20	0·20	0·20	0·20	0·20	0·20	0·20	—	—	
B‖					0·29	0·34	0·402	0·515	0·577	0·687	0·749	0·921	0·984	1·155	
P				3/64	1/16	1/16	1/16	3/32	3/32	1/8	1/8	3/32	—	—	
Drill No.				55	50	50	50	37	37	29	29	19	—	—	

* Ordinary nut. † Thin or lock nut. ‡ Slotted nut. § Plain and slotted shear nuts. ‖ Castle nuts.

	4/40	6/32	8/32	10/24 10/32	1/4	5/16	3/8	7/16	1/2	9/16	5/8	3/4	7/8	1·0	Specification
A	0·188	0·25	0·313	0·313											BS 1981
E	0·216	0·289	0·361	0·361											
B	0·098	0·114	0·130	0·130											
A	0·25	0·313	0·344	0·375	0·438	0·563	0·625	0·75	0·813	—	1·0	1·125	1·313	1·5	BS 1981 (4/40 to 3/4 in. pressed type) BS 2708 (1/4 to 1·0 pressed type, square only)
E*	0·289	0·361	0·397	0·433	0·505	0·649	0·722	—	—	—	—	—	—	—	
E†	0·354	0·442	0·486	0·530	0·619	0·796	0·884	1·061	1·149	—	1·414	1·591	1·856	2·121	
B‡	0·087	0·114	0·130	0·130	0·193	0·223	0·257	—	—	—	—	—	—	—	
B§	—	—	—	—	0·235	0·283	0·346	0·394	0·458	—	0·569	0·680	0·792	0·903	

*Hexagon nut. † Square nut. ‡ BS 1981 only. § BS 2708 only.

STIFF NUTS

	4/40	6/32	8/32	10/24 10/32	1/4	5/16	3/8	7/16	1/2	9/16	5/8	3/4	7/8	1·0	Specification
A	0·188	0·25	0·312	0·344	0·438	0·50	0·562	0·688	0·75	0·875	0·938	1·062	1·25	1·438	(See footnote)
E	0·217	0·289	0·361	0·397	0·505	0·577	0·650	0·794	0·866	1·01	1·083	1·227	1·443	1·66	
L*	0·175	0·215	0·275	0·285	0·34	0·41	0·49	0·57	0·66	0·725	0·81	0·975	1·085	1·245	
L†	0·143	0·179	0·233	0·241	0·273	0·326	0·386	0·445	0·514	0·558	0·623	0·746	0·835	0·953	
L‡	—	—	0·517	0·529	0·685	0·735	0·84	0·946	1·045	—	—	—	—	—	

* **Ordinary nuts:** *A 125, steel; A 127, cadmium plated, corrosion resistant; A 180, Silver plated, corrosion resistant; A 129, aluminium alloy; and A 131, tinned brass or bronze.*
† **Thin or locknuts:** *A 126, steel; A 128, cadmium plated, corrosion resistant; A 181, silver plated, corrosion resistant; A 130, aluminium alloy; and A 132, tinned brass or bronze.*
‡ **Cap nuts:** *A 133, steel; A 134, cadmium plated, corrosion resistant; and A 135, aluminium alloy.*

CLINCH NUTS

A	0·25	0·312	0·344	0·438	0·50	0·562	0·688								A 122, steel (S 112 below 1/4 in., S 113 1/4 and above) A 123, brass or bronze (B11, B 251 or B 369) A 124, aluminium alloy L 64
E	0·289	0·361	0·397	0·506	0·577	0·649	0·794								
L	0·145	0·185	0·233	0·241	0·273	0·326	0·386								
N	0·193	0·255	0·286	0·317	0·380	0·443	0·567								

SPLIT PINS

	BA Threads					BSW, BSF and Unified Threads											
	2	3	4	5	6	1/8	3/16	1/4	5/16	3/8	7/16	1/2	9/16	5/8	3/4	7/8	1·0	
Pin dia. (P)	1/16							1/16	1/16	1/16	3/32	3/32	1/8	1/8	5/32	5/32	3/16	SP 9
Drill No.	50							50	50	50	37	37	29	29	19	19	8	

SPRING WASHERS FOR BA THREADS

	0	1	2	3	4	5	6	8	10	Specification
D*	0·411	0·353	0·229	0·273	0·254	0·222	0·206	0·159	0·139	BS 2061
T*(s.w.g.)	15	16	16	18	18	19	19	21	21	
(in.)	0·072	0·064	0·064	0·048	0·048	0·04	0·04	0·032	0·032	
D†	0·451	0·409	0·385	0·337	0·286	0·238	0·222	—	—	
T†(s.w.g.)	16	18	18	20	20	21	21	—	—	
(in.)	0·064	0·048	0·048	0·036	0·036	0·032	0·032	—	—	
D‡	0·451	0·385	0·361	0·305	0·286	0·238	0·222	—	—	
T‡(s.w.g.)	18	20	21	21	21	21	21	—	—	
(in.)	0·048	0·036	0·032	0·032	0·032	0·032	0·032	—	—	

* Square section. † Rectangular section. ‡ Double coil.

SPRING WASHERS FOR BA AND FRACTIONAL THREADS

	1/8 and 6BA	5/32 and 4BA	3/16 and 2BA	1/4	5/16	3/8	7/16	1/2	9/16	5/8	3/4	7/8	1·0	Specification
D*	0·205	0·252	0·33	0·425	0·503	0·590	0·677	0·763	0·880	0·976	1·165	1·36	1·526	BS 1802
T* (s.w.g.)	21	19	16	15	14	13	12	11	10	9	7	5	4	
(in.)	0·032	0·04	0·064	0·072	0·08	0·092	0·104	0·116	0·128	0·144	0·176	0·212	0·232	
D†	0·237	0·3	0·387	0·465	0·6	0·694	0·789	0·851	1·009	1·072	1·276	1·442	1·624	
T† (s.w.g.)	21	21	18	16	16	16	16	13	13	10	10	10	—	
(in.)	0·032	0·032	0·048	0·064	0·064	0·064	0·064	0·092	0·092	0·128	0·128	0·128	0·187	
W†	0·048	0·064	0·092	0·092	0·128	0·144	0·160	0·160	0·192	0·192	0·232	0·232	0·281	
D‡	0·253	0·284	0·316	0·421	0·526	0·110	0·693	0·755	0·876	0·967	1·14	1·265	1·418	
T‡ (s.w.g.)	16	16	16	14	12	11	10	10	9	8	—	—	—	
(in.)	0·064	0·064	0·064	0·08	0·104	0·116	0·128	0·128	0·144	0·165	0·187	0·187	0·203	
W‡	0·056	0·056	0·056	0·07	0·091	0·102	0·112	0·112	0·126	0·140	0·164	0·164	0·178	
D§	—	—	0·344	0·463	0·548	0·658	0·749	0·839	0·960	1·059	1·25	1·429	1·608	
T§ (s.w.g.)	—	—	14	12	11	9	8	7	6	5	—	—	—	
(in.)	—	—	0·08	0·104	0·116	0·144	0·16	0·176	0·192	0·212	0·25	0·281	0·312	
W§	—	—	0·07	0·091	0·102	0·126	0·14	0·154	0·168	0·186	0·219	0·246	0·273	
D‖	0·237	0·3	0·364	0·513	0·576	0·694	0·757	0·851	1·008	1·071	1·236	1·407	1·566	
T‖ (s.w.g.)	21	21	21	19	18	18	16	16	16	14	14	13	10	
(in.)	0·032	0·032	0·032	0·04	0·048	0·048	0·064	0·064	0·064	0·08	0·08	0·092	0·128	
W‖	0·048	0·064	0·08	0·116	0·116	0·144	0·144	0·160	0·192	0·192	0·212	0·232	0·252	

* *Square section.* † *Rectangular section.* ‡ *Light series girder section.* § *Heavy series girder section.* ‖ *Double coil spring washers.*

SPRING WASHERS FOR BSF, BSW AND UNIFIED THREADS

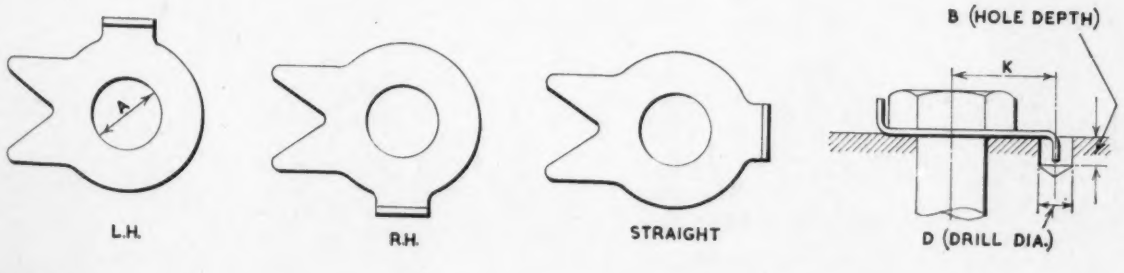
	1/8	5/32	3/16	1/4	5/16	3/8	7/16	1/2	9/16	5/8	3/4	Specification
D*	0·221	0·268	0·331	0·425	0·503	0·590	0·701	0·787	0·880	0·976	1·165	BS 2061
T* (s.w.g.)	19	18	16	15	14	13	11	10	10	9	7	
(in.)	0·04	0·048	0·064	0·072	0·08	0·092	0·116	0·128	0·128	0·144	0·176	
D†	0·237	0·3	0·387	0·465	0·6	0·694	0·789	0·915	1·009	1·072	1·276	
T† (s.w.g.)	21	20	18	16	16	16	16	13	13	10	10	
(in.)	0·032	0·036	0·048	0·064	0·064	0·064	0·064	0·092	0·092	0·128	0·128	
D‡	0·237	0·3	0·363	0·465	0·576	0·694	0·757	0·851	1·009	1·072	1·236	
T‡ (s.w.g.)	21	21	18	18	18	18	16	16	16	14	14	
in.)	0·032	0·032	0·032	0·048	0·048	0·048	0·064	0·064	0·064	0·08	0·08	

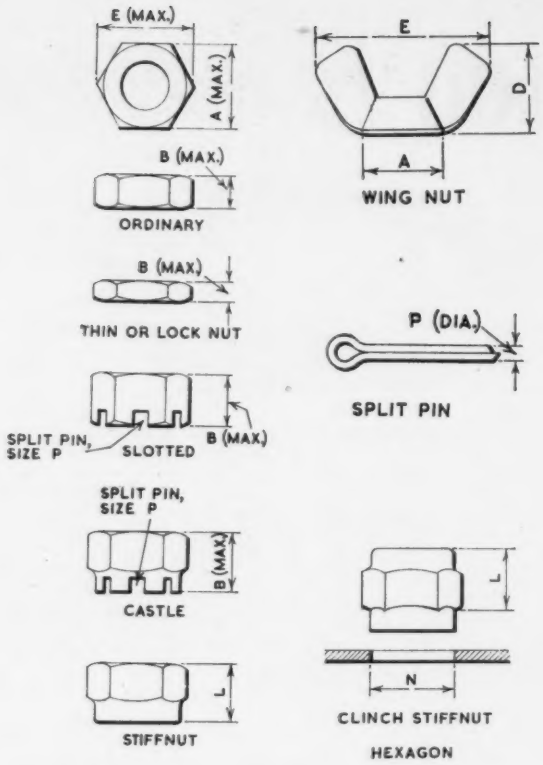
* *Square section.* † *Rectangular section.* ‡ *Double coil.*

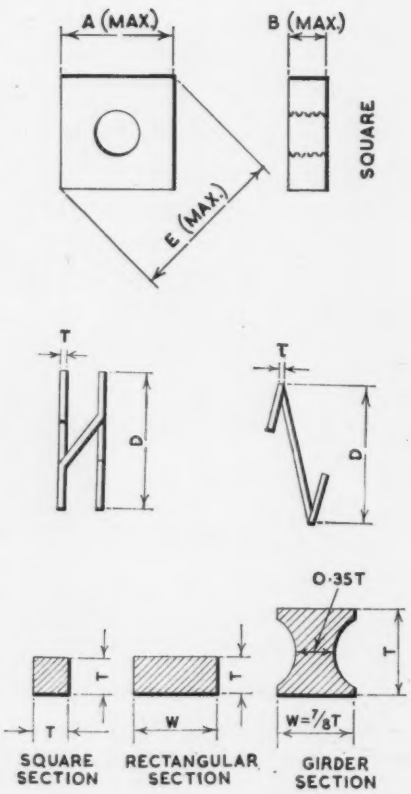
TAB WASHERS FOR BA AND FRACTIONAL THREADS

A (Nominal)	2 BA	1/4	5/16	3/8	7/16	1/2	9/16	5/8	3/4	7/8	1·0	Specification
D	1/4	1/4	5/16	5/16	5/16	7/16	7/16	7/16	1/2	9/16	5/8	SP 41 to 46 (BA and BSF), SP 107 to 112 (unified)
B	0·105	0·115	0·115	0·155	0·165	0·165	0·165	0·165	0·165	0·165	0·165	
C* (s.w.g.)	22	20	20	20	20 s.w.g.							
(in.)	0·028	0·036	0·036	0·036								
C† (s.w.g.)	24	21	21	21	0·036							
(in.)	0·022	0·032	0·032	0·032								
K	0·225	0·275	0·335	0·375	0·425	0·475	0·55	0·575	0·675	0·80	0·875	

* *Steel to S 511.* † *Non-corrodible steel to S 521.*




E (MAX.)
A (MAX.)
B (MAX.)
ORDINARY
B (MAX.)
THIN OR LOCK NUT
SPLIT PIN, SIZE P
SLOTTED
B (MAX.)
SPLIT PIN, SIZE P
B (MAX.)
CASTLE
L
STIFFNUT
E
D
A
WING NUT
P (DIA.)
SPLIT PIN
L
N
CLINCH STIFFNUT
HEXAGON


A (MAX.)
B (MAX.)
SQUARE
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T
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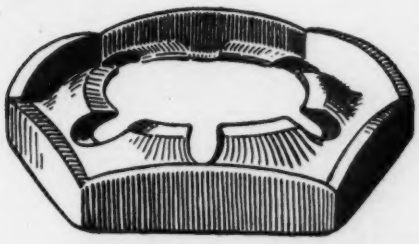
W=7/8T
SQUARE SECTION
RECTANGULAR SECTION
GIRDER SECTION

EMD 6922 for further information

100%



'PALNUT' SAFETY LOCK WASHERS
(REGD. TRADE MARK)

DID NOT FAIL!

We give below an extract from a report of a test given to PALNUT SAFETY LOCK WASHERS at the National Physical Laboratory, Teddington.

CONCLUSIONS

The "Palnut" locking device did not fail during tests lasting in all 83 hours during which the oscillator made 6,298,000 cycles, although during the run 17 bolts and one bar of the frame were fractured. Measurement of the torque required to loosen the nuts after test gave an average torque slightly in excess of that required to slacken bolts which had not been subject to vibration.

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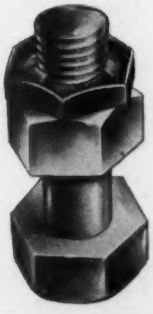
RAILWAYS · SHIPBUILDERS
CONSTRUCTIONAL ENGINEERS
ELECTRICAL EQUIPMENT
MOTOR CAR and VIBRATING EQUIPMENT MANUFACTURERS

'PALNUT' IN SERVICE ↓

SPINS ON—
STAYS LOCKED



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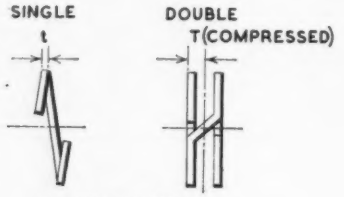
Telephone 70427 *Telegrams PALNUT HOVE*

SPRING WASHERS FOR BA THREADS

	0	1	2	3	4	5	6	8	10	Specification
T			0·064		0·064		0·064			SP 55
t (s.w.g.)			18		20		20			SP 56
t (in.)			0·048		0·036		0·036			SP 47

SPRING WASHERS FOR BSF, BSW AND UNIFIED THREADS

	1/8	5/32	3/16	1/4	5/16	3/8	7/16	1/2	9/16	5/8	3/4	Specification
T*				0·080	0·096	0·096	0·128	0·128	0·128	0·160		SP 55
T†				0·096	0·096	0·096	0·128	0·128	0·128	0·160		SP 56
t (s.w.g.)				17	16	15	15	14	13	12		SP 47
t (in.)				0·056	0·064	0·072	0·072	0·080	0·092	0·104		



SPRING WASHERS
(SP 47, 55 AND 56)

WASHERS FOR BA THREADS

	0	1	2	3	4	5	6	8	10	12	14	16	Specification
A	0·256	0·228	0·20	0·177	0·157	0·14	0·123	0·099	0·078				BS 57 (large)
B	0·625	0·565	0·50	0·432	0·378	0·335	0·288	0·228	0·176				
C (s.w.g.)	17	18	18	19	19	20	20	25	27				
(in.)	0·056	0·048	0·048	0·040	0·040	0·036	0·036	0·020	0·016				
A	0·256	0·228	0·20	0·177	0·157	0·14	0·123	0·099	—				BS 57 (small)
B	0·5	0·443	0·391	0·341	0·301	0·268	0·233	0·185	—				
C (s.w.g.)	19	20	21	22	22	23	23	25	—				
(in.)	0·040	0·036	0·032	0·028	0·028	0·024	0·024	0·020	—				
A			0·20										BS 1083
B*			0·5										
C* (s.w.g.)			18										
(in.)			0·048										
B†			3/8										
C† (s.w.g.)			21										
(in.)			0·032										

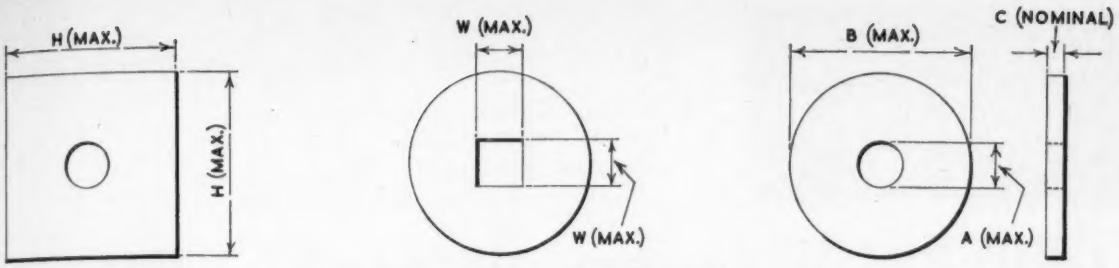
* *Large washer.* † *Small washer.*

A			0·202		0·157		0·123						SP 10, 11, 13, 14, 15 and 16
B			0·391		0·301		0·233						
C* (s.w.g.)			26		26		26						
(in.)			0·018		0·018		0·018						
C† (s.w.g.)			18		18		18						
(in.)			0·048		0·048		0·048						
C‡ (s.w.g.)			12		12		12						
(in.)			0·104		0·104		0·104						

* *Facing washers.* † *Plain washers (thin).* ‡ *Plain washers (thick).*

A			0·202		0·157		0·123						SP 18 and 19
B			1·26		1·01		1·01						
C (s.w.g.)			16		16		16						
(in.)			0·064		0·064		0·064						
A			0·202		0·157		0·123	0·099	0·078				SP 22, 23, 24, 25, 26 and 27
B*			0·391		0·301		0·233	0·185	—				
C* (s.w.g.)			21		22		23	25	—				
(in.)			0·032		0·028		0·024	0·025	—				
B†			0·50		0·378		0·288	0·228	0·175				
C† (s.w.g.)			18		19		20	25	27				
(in.)			0·048		0·04		0·036	0·020	0·016				

* *Small instrument washers.* † *Large instrument washers.*



WASHERS FOR FRACTIONAL THREADS

	1/8	5/32	3/16	7/32	1/4	5/16	3/8	7/16	1/2	9/16	5/8	3/4	7/8	1·0	Specification
A					9/32	11/32	7/16	1/2	9/16	5/8	11/16	13/16	15/16	1 1/16	BS 916
B					5/8	3/4	1	1 1/8	1 1/4	1 3/8	1 1/2	1 5/8	1 7/8	2 1/4	
C (s.w.g.)					16	16	16	12	12	12	10	10	10	6	
(in.)					0·064	0·064	0·064	0·104	0·104	0·104	0·128	0·128	0·128	0·192	
A					9/32	11/32	7/16	1/2	9/16	—	11/16	13/16	15/16	1 1/16	BS 325 (round washers with round holes)
B					5/8	3/4	7/8	1·0	1 1/8	—	1 3/8	1 5/8	1 7/8	2 1/4	
C (s.w.g.)					16	14	14	12	12	—	10	9	8	7	
(in.)					0·064	0·08	0·08	0·104	0·104	—	0·128	0·144	0·160	0·176	
W							7/16	1/2	9/16	—	11/16	13/16	15/16	1 1/16	BS 325 (round washers with square holes)
B							1 1/2	1 3/8	1 1/2	—	2	2 1/4	2 5/8	3	
C (s.w.g.)							11	10	10	—	9	8	5	5	
(in.)							0·116	0·116	0·128	—	0·144	0·160	0·212	0·212	
A							7/16	1/2	9/16	—	11/16	13/16	15/16	1 1/16	BS 325 (square washers with round holes)
H*							2·0	2·0	2·0	—	2·0	2·0	2·0	—	
H†											3·0	3·0	3·0	3·0	
H‡											—	4·0	4·0	4·0	

* Size 1—1/8 in. thick. † Size 2—1/4 in. thick. ‡ Size 3—1/4 in. thick.

A					0·27	0·333	0·395	0·458	0·52	0·583	0·645	0·77	0·895	1·025	SP 10, 11, 13, 14, 15 and 16
B					0·52	0·61	0·70	0·82	0·95	1·07	1·17	1·39	1·5	1·71	
C*(s.w.g.)					←				26	→					
(in.)					←				0·018	→					
C†(s.w.g.)					←				18	→					
(in.)					←				0·048	→					
C‡(s.w.g.)					←				12	→					
(in.)					←				0·104	→					

* Facing washers. † Thin plain washers. ‡ Thick plain washers.

A					0·27	0·333	0·395	0·458	0·52						SP 18 and 19
B					1·26	1·26	1·51	1·51	1·51						
C (s.w.g.)					16	16	14	14	14						
(in.)					0·064	0·064	0·08	0·08	0·08						
A					0·27	0·333	0·395	0·458	0·52	0·593	0·656	0·781	0·906	1·031	BS 1083
B					9/32	5/8	3/4	7/8	1·0	1 1/8	1 1/4	1 1/2	1 3/4	1 7/8	
C (s.w.g.)					17	15	15	13	13	12	11	9	9	8	
(in.)					0·056	0·072	0·072	0·092	0·092	0·104	0·116	0·144	0·144	0·160	

WASHERS FOR UNIFIED THREADS

	4/40	6/32	8/32	10/24 10/32	1/4	5/16	3/8	7/16	1/2	9/16	5/8	3/4	7/8	1·0	Specification
A	0·125	0·151	0·179	0·205	0·27	0·333	0·395	0·458	0·520	0·583	0·645	0·770	0·895	1·020	SP 122, 123, 124, 125, SP 126 and 127
B	0·22	0·295	0·365	0·40	0·515	0·585	0·66	0·805	0·875	1·02	1·095	1·235	1·455	1·67	
C*(s.w.g.)	←							18						→	
(in.)	←							0·048						→	
C†(s.w.g.)	←							12						→	
(in.)	←							0·104						→	
C‡(s.w.g.)	←							26						→	
(in.)	←							0·018						→	

* Thin plain washer. † Thick plain washer. ‡ Facing washers.

A									9/16	—	11/16	13/16	15/16	1 1/16	BS 3139
B									1 1/8	—	1 3/8	2·0	2 1/4	2 1/2	
C (s.w.g.)									12	—	10	9	8	8	
(in.)									0·104	—	0·128	0·144	0·16	0·16	

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GROVERLOK ensures permanent tightness

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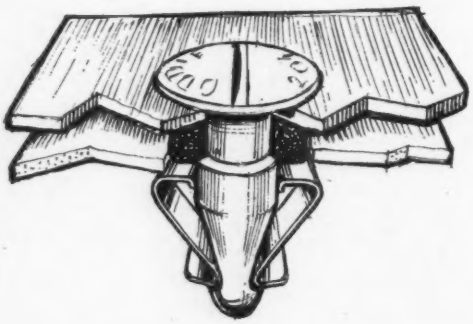

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WASHERS FOR UNIFIED THREADS (cont.)

	4/40	6/32	8/32	10/24 10/32	1/4	5/16	3/8	7/16	1/2	9/16	5/8	3/4	7/8	1·0	Specification
A					0·27	0·333	0·395	0·458	0·52	0·593	0·656	0·781	0·906	1·031	BS 1768
B					9/16	5/8	3/4	7/8	1·0	1 1/8	1 1/4	1 1/2	1 5/8	1 7/8	
C (s.w.g.)					17	15	15	13	13	12	11	9	9	8	
(in.)					0·056	0·072	0·072	0·092	0·092	0·104	0·116	0·144	0·144	0·160	
A									9/16	—	11/16	13/16	15/16	1 1/16	BS 1769
B									1 1/8	—	1 1/8	1 5/8	1 7/8	2 1/8	
C (s.w.g.)									12	—	10	9	8	7	
(in.)									0·104	—	0·128	0·144	0·160	0·176	
A	0·123	0·157	0·177	0·202	0·270	0·333	0·395	0·458	0·52	—	0·656	0·781	—	—	BS 1981 (large plain)
B	0·288	0·378	0·432	0·5	9/16	5/8	3/4	7/8	1·0	—	1 1/4	1 1/2	—	—	
C (s.w.g.)	20	19	19	18	17	15	15	13	13	—	11	9	—	—	
(in.)	0·036	0·040	0·040	0·048	0·056	0·072	0·092	0·092	0·092	—	0·116	0·144	—	—	
A	0·123	0·157	0·177	0·202											BS 1981 (small plain)
B	0·233	0·301	0·341	0·391											
C (s.w.g.)	23	22	22	21											
(in.)	0·024	0·028	0·028	0·032											
A					9/32	11/32	7/16	1/2	9/16	—	11/16	13/16	15/16	1 1/16	BS 2708
B					5/8	3/4	7/8	1	1 1/8	—	1 1/4	1 1/2	1 7/8	2 1/8	
C (s.w.g.)					16	16	16	12	12	—	10	10	10	6	
(in.)					0·064	0·064	0·064	0·104	0·104	—	0·128	0·128	0·128	0·192	

RIVET BURRS FOR AIRCRAFT PURPOSES

A	1/16	3/32	1/8	5/32	3/16	7/32	1/4	9/32	5/16	11/32	3/8	Specification
B	0·35	0·4	0·45	0·55	0·65	0·7	0·8	0·85	0·9	1·0	1·1	SP 57 (Copper to BS 899)
C	22 s.w.g. (0·028)					20 s.w.g. (0·036)				18 s.w.g. (0·048)		SP 58 (Aluminium alloy to L70)

STANDARD SPECIFICATIONS

(Figures quoted are minimum values.)

SPECIFICATION	TITLE	MATERIAL AND REMARKS
BS 57	BA screws, bolts, nuts and plain washers.	Steel 25 t.s.i., brass and aluminium alloy 20 t.s.i.
BS 325	Black cup and countersunk bolts, nuts and washers (BSW).	Steel 26 t.s.i.
BS 450	Machine screws and machine screw nuts (BSW and BSF).	Steel 25 t.s.i., brass and aluminium alloy 20 t.s.i.
BS 856	Wing nuts (BA, BSF and BSW).	Brass, iron and steel.
BS 916	Black bolts, screws and nuts (hexagon and square) (BSW and and BSF).	Steel 26 t.s.i. and 20% elongation, or 28 t.s.i. and 17% elongation.
BS 1083	Precision hexagon bolts, screws, nuts and plain washers (BSW and BSF).	Steel 25 t.s.i., brass and aluminium alloy 20 t.s.i.
BS 1750	Bolting for the petroleum industry.	—
BS 1768	Unified precision hexagon bolts, screws, nuts and plain washers (normal series) (UNC and UNF).	Steel, as code number on bolt head: B = 28–35 t.s.i.; P = 35–45 t.s.i.; R = 45–55 t.s.i.; T = 55–65 t.s.i.; V = 75–85 t.s.i.
BS 1769	Unified black hexagon bolts and screws, nuts and plain washers (heavy series) (UNC and UNF).	Steel to BS EN3A.
BS 1802	Spring steel washers.	Steel to BS EN42.
BS 1981	Unified machine screws and nuts.	Steel 25 t.s.i., brass and aluminium alloy 20 t.s.i.
BS 2061	Phosphor bronze spring washers.	Phosphor bronze.
BS 2708	Unified black square and hexagon bolts, screws, nuts and plain washers (normal series).	Steel 26 t.s.i. and 20% elongation or 28 t.s.i. and 17% elongation.
BS 2827	Machine screw nuts pressed type (BA, BSF and BSW).	Steel 25 t.s.i., brass 20 t.s.i.
BS 3139	High strength friction grip bolts, nuts (hexagon heads) and washers.	Steel (heat-treated).
BS Aircraft Series		
A 14	Hexagonal brass nuts for aircraft purposes.	Brass to BS B13 or 249.
A 24	High-tensile stainless steel hexagon-head nuts (ordinary, thin, slotted and castle) for aircraft purposes.	S80.
A 27	Medium-tensile steel hexagon nuts (ordinary, thin, slotted and castle) for aircraft purposes.	S112 for sizes 2, 4 and 6 BA. S113 for sizes 1/4 to 1/2 in. inclusive. S114 or 117 for sizes over 1/2 in.
A 29	Aluminium alloy hexagon nuts (ordinary and slotted) for aircraft purposes.	L65.

STANDARD SPECIFICATIONS (cont.)

A31–54	*BA low tensile screws and nuts for aeronautical purposes*	
A 47	Ordinary nuts.	Mild steel, 25 t.s.i.
A 48	Thin nuts.	
A 49	Ordinary nuts.	Stainless steel to BS 970, EN 57 or 58, 35 t.s.i.
A 50	Thin nuts.	
A 51	Ordinary nuts.	Aluminium alloy to BS 1475, HG 14(T), MG 15(W) or NG 6(M), 20 t.s.i.
A 52	Thin nuts.	
A 53	Ordinary nuts.	Brass, 20 t.s.i.
A 54	Thin nuts.	
A 58	Nuts for shear bolts.	S95, S96 or S94.
A 103	Steel nuts (unified hexagons and threads—Ordinary, thin, slotted and castle) for aircraft purposes.	S112, S113 or S92 for sizes 4/40 and 10/32. S113 for sizes $\frac{1}{4}$ to $\frac{1}{2}$ in. S114 or 117 for sizes over $\frac{1}{2}$ in.
A 105	Corrosion-resisting steel nuts (unified hexagons and threads—ordinary, thin, slotted and castle) for aircraft purposes.	S80 or DTD 715.
A 107	Aluminium alloy nuts (unified hexagons and threads—ordinary and slotted) for aircraft purposes.	L65.
A 110	Nuts for shear bolts. (Unified hexagons and threads) for aircraft purposes.	
A 122	Clinch nuts (unified threads) for aircraft.	Steel to S112 below $\frac{1}{4}$ in. to S113 $\frac{1}{4}$ in. and above.
A 123	,,	Brass or bronze to B11, B251 and B369.
A 124	,,	Aluminium alloy L64.
A 125	Stiffnuts (unified threads) for aircraft.	Steel.
A 126	,,	Steel.
A 127	,,	Steel.
A 128	,,	Corrosion-resistant steel, cadmium plated.
A 129	,,	,, , silver plated.
A 130	,,	Aluminium alloy, anodised.
A 131	,,	Brass or bronze, tinned.
A 132	,,	Brass or bronze, tinned.
A 133	,,	Steel.
A 134	,,	Corrosion-resistant steel, cadmium plated.
A 135	,,	Aluminium alloy, anodised.
A 180	Stiffnuts (unified threads).	Corrosion-resistant steel, silver plated.
A 181	Stiffnuts (unified threads)	,,
A 186	Stiffnuts (unified threads), double lug fixed anchor (ordinary).	,,
A 187	Stiffnuts (unified threads), double lug fixed anchor (thin).	,,
A 192	Stiffnuts (unified threads), double lug floating anchor (ordinary).	,,
A 193	Stiffnuts (unified threads), double lug floating anchor (thin).	,,
A 200	Stiffnuts (unified threads), single lug fixed anchor (ordinary).	,,
A 201	Stiffnuts (unified threads), single lug fixed anchor (thin).	,,
A 210	Brass nuts (unified hexagons and threads) for aircraft.	Brass to BS 249.
SP 9	Split cotter pins.	Non-corrodible steel.
SP 10	Facing washers.	Cold rolled steel.
SP 11	Facing washers.	Stainless steel.
SP 13	Plain washers, thin	Mild steel.
SP 14	Plain washers, thin.	Stainless steel.
SP 15	Plain washers, thin.	Aluminium alloy.
SP 16	Plain washers, thick.	Aluminium alloy.
SP 18	Timber washers.	Cold rolled mild steel.
SP 19	Timber washers.	Stainless steel.
SP 22	Instrument washers, large.	Tin-plated brass.
SP 23	Instrument washers, large.	Cadmium-plated steel.
SP 24	Instrument washers, large.	Cr–Ni rust-, acid- and heat-resisting steel.
SP 25	Instrument washers, small	Tin-plated brass.
SP 26	Instrument washers, small.	Cadmium-plated steel.
SP 27	Instrument washers, small.	Cr–Ni rust-, acid- and heat-resisting steel.
SP 47	Single spring washer.	Steel.
SP 55	Double spring washer.	Steel.
SP 56	Double spring washer.	Phosphor bronze.
SP 122	Thin washers for use with unified bolts (primarily for packing).	Mild steel to S510.
SP 123	,,	Stainless steel to S521.
SP 124	,,	Aluminium alloy to L 72.
SP 125	,,	Aluminium alloy to L72.
SP 126	Washers for unified hexagons for aircraft purposes (primarily for facing).	Steel to S514.
SP 127	Washers for unified hexagons for aircraft purposes (primarily for facing).	Corrosion-resisting steel to S521.
SP 41–46	*Tab washers for aircraft (BA and BSF)*	
SP 41	Tab washers for aircraft, straight tab.	Carbon steel to S511.
SP 42	Tab washers for aircraft, straight tab.	Non-corrodible steel to S521.
SP 43	Tab washers for aircraft, right-angled tab.	Carbon steel to S511.
SP 44	Tab washers for aircraft, right-angled tab.	Non-corrodible steel to S521.
SP 45	Tab washers for aircraft, left-angled tab.	Carbon steel to S511.
SP 46	Tab washers for aircraft, left-angled tab.	Non-corrodible steel to S521.
SP 107–112	*Tab washers for aircraft (unified)*	
SP 107	Tab washers for aircraft, straight tab.	Carbon steel to S511.
SP 108	Tab washers for aircraft, straight tab.	Non-corrodible steel to S521.
SP 109	Tab washers for aircraft, right-angled tab.	Carbon steel to S511.
SP 110	Tab washers for aircraft, right-angled tab.	Non-corrodible steel to S521.
SP 111	Tab washers for aircraft, left-angled tab.	Carbon steel to S511.
SP 112	Tab washers for aircraft, left-angled tab.	Non-corrodible steel to S521.

New Books

Creative Engineering Design. *By Harold R. Buhl. (The Iowa State University Press—$4.95.)*

This book won the 1960 Iowa State University Press Award for the most significant new book by a faculty member. It deals not with the technical knowledge we use in design, but with the thinking methods we adopt or can adopt to utilise this material to the best advantage. The hope is that, by illuminating this field through understanding, many potential creative thinkers may be led to break their shackles. A book like this cannot automatically make us into creative designers —whatever we become is ultimately through our own efforts—but it can help us to channel our thoughts and adopt recognisable patterns of working.

The author deals first with problem solving in general, and subsequent chapters expand this into the field of design, in which problems have no one unique answer, and of which the solutions are always some function of the persons engaged upon the work.

The Americans have tackled this subject with vigour, and their thinking is somewhat in advance of that in the British design world. This is partly because the need is greater; their industrial economy requires innovation—at times even novelty —to keep ticking; their methods of education and of design team work have, until recently, not provided sufficient fertile ground for individual creative development. On the other hand, in the U.S.A. the professors of university engineering departments are both closer to industry and to other faculties than here; engineering is seen more clearly to be a human activity rather than just applied science. Over the years there has been an interplay between engineering educators and psychological researchers which has resulted in creativity becoming a well-documented primary topic in the U.S.A.

Creative Engineering Design is not one man's fanciful views. It is a condensation, by a design engineer and educator, of the results of widespread investigation by many persons and groups over a long period. The patterns which have emerged match up very well with those found in this and other countries by independent investigators. The result is a sound, stimulating document which nobody interested in the process of design or the training of designers can afford to miss.

The work is centred more around "creativity" than "engineering design" for, although a "creative" design has to be followed through the same as any other design, the accent is on the beginning, the "idea getting". Nevertheless, all design is creative to a greater or lesser degree, and the patterns of thinking isolated and discussed in this book are appropriate to all design work.

Apart from the main themes, reading between the lines the astute British reader will be able to discern much about American ways of thinking and motivations. In Britain we are apt to think of a designer as someone who uses accepted methods of solving engineering problems except when these prove to be inadequate—that is, "the designer has novelty forced on him, he does not seek it", as has recently been said in Britain. However, in Buhl's work great emphasis is placed on the idea that it is the designer's responsibility to innovate at all times, and to sell his ideas to management. Does this arise through a difference in terminology, i.e. whether one considers design to embrace invention or not? Or does it show a different national outlook? Whether the designer considers himself to be a passive implementer of ideas, or an active participant in a changing material world could be very important in the future, both for designers and their country.

The book is very readable, although it contains sufficient meat to warrant a second and third reading; it has many amusing but well-chosen illustrations, which the more staid British reader might not take to, and a selection of thought-provoking quotations; it ends with sixty-six general problems to make one think—and they most certainly do.

P. J. Booker

Drawing Office Organisation. *(British Institute of Management—15s.)*

This revised edition of a work published in 1951 is designed to assist management in making decisions regarding the operation and control of drawing offices.

Commendable prominence is given to the various methods of office lighting, which is discussed in detail, with attention being drawn to the recommendations of the British Illuminating Engineering Society. Consideration accorded to this subject, and to the passages relating to office and print room layout, could prove particularly rewarding to those commissioned to establish new drawing offices. The duties and responsibilities normally assigned to respective drawing office personnel are delineated, with useful suggestions and guidance on routine, training problems and the efficient employment of trained draughtsmen.

Several pages are devoted to a compact but comprehensive study of the institution and operation of a standards section, while another too often neglected subject —that of co-operation and consultation between design and production departments—receives its due emphasis. The booklet is well illustrated to cover office layout, lighting, printing machines and filing systems.

A. H. Roach

Field Computations in Engineering and Physics. *By A. Thom and C. J. Apelt. (D. Van Nostrand Co. Ltd.—30s.)*

With the advent of the electronic computer, the possibility of a fresh attack on those partial differential equations hitherto intractable by normal mathematical methods has become a practical reality. Before a computer can be programmed to carry out this work, however, it is necessary for the problem to be reduced to one in numerical analysis. Thanks to the pioneer work done in this field by a few individuals with desk calculators, methods exist by which certain problems can already be attacked. This unglamorous branch of mathematics calls for great patience and industry and has, therefore, somewhat naturally, not attracted the attention of a large number of mathematicians. The basis of the authors' methods depends on the well-known fact that the equation of Laplace, $\nabla^2 f = 0$, can be interpreted as a statement that the value of the function f at a point is equal to the average value of the function at neighbouring points in the region for which the equation applies. After describing in fairly elementary terms numerical solutions for the equations of Laplace and Poisson, the authors deal with some of the difficulties met with because of singularities and non-rectangular boundary conditions, making use of conformal transformation theory. The most interesting part of the book is that which deals with fluid flow for both uncompressible and compressible fluids under steady-state conditions. This field is full of problems awaiting solution which must be essentially numerical in character.

It seems a pity that, although it is stated that these problems have been programmed for a Ferranti Mercury computer, no statement is made to enable a comparison of the time taken by desk machines and computers to be made.

F. Westwater

Polypropylene. *By Theodore O. J. Kresser (Reinhold; Chapman & Hall—52s.)*

Any publication dealing with new materials such as polypropylene is most welcome. Here is a new thermoplastic that will find use in many industries, especially those already using plastics such as polyethylene, which may have undesirable characteristics. This publication will be of great value to those who wish to keep right up to date with modern trends and developments.

The book is divided into nine chapters which cover all aspects of polypropylene, the properties, chemistry, production and processing being well described. In the chapter devoted to chemistry, the author has described the work carried out by Professor Guillo Natta on the discovery, in 1954, and subsequent development of polypropylene. Later chapters illustrate the possible application that this thermoplastic has in such industries as packaging, durable goods and soft goods. A chapter is also devoted to possible future developments of this material, illustrating many new applications in which it could be used with advantage.

Readers of this book will find it extremely useful, both as a reference book and for general information. In addition to being written in an easy-to-follow and interesting style, it is also well illustrated, and contains sufficient basic information of stereochemistry to point out the unique qualities and advantages of polypropylene.

F. Smith

New Books (cont. from page 469)

Corrosion Prevention. Part M of Maintenance and Operation of Public Works and Public Utilities. (*United States Department of Commerce —$6.*)

Although this publication has been prepared as a technical guide for personnel responsible for the construction, operation and maintenance of naval shore facilities, it contains a mass of useful information for anyone connected with corrosion. For example, there is a section of some eleven pages devoted to definitions, wherein are defined such terms as cathodic protection (the reduction or prevention of corrosion of a metal surface by making it cathodic to the electrolyte, by, for example, the use of sacrificial anodes or impressed currents). Then again, tuberculation is given as "the formation of localised corrosion products scattered over the surface in the form of knob-like mounds".

Newly-developed data are assembled on atmospheric, submerged and sub-surface corrosion, as well as data on areas alternately wet and dry. The latest and most practicable methods and materials for controlling or minimising corrosion are described in detail. Certain new materials, including the plastics, are described as being very effective in reducing or even eliminating some forms of corrosion.

The cathodic protection techniques described should be of value in the control of corrosion on above-ground structures, underground structures, and marine structures that are permanently submerged.

The cost of corrosion is quoted as 10,000 million dollars a year in the U.S.A., a truly staggering figure. The toll that corrosion exacts is amazing; responsible estimates of the portion of the U.S. annual steel production used to replace corroded steel run as high as 40 per cent. Such estimates include only the costs attributed to corrosion control and replacement of damaged equipment and structures. They do not include any of the various indirect losses.

W. L. Morse

A Guide to Technical Writing. *By C. Baker. Sir Isaac Pitman & Sons Ltd. —15s.*)

Since the last war, two very closely allied activities—technical illustration and technical writing—have been recognised as subjects in their own right, with rules and techniques of their own which should be mastered by their practitioners. Both subjects are now covered by City and Guilds courses and have their appropriate examinations. Technical writing has so far had most attention—which is natural as technical writers are obviously in a better position to write books than illustrators, who work in a different medium —with the result that there are probably more books on report writing and technical authorship than the market can bear.

Why, then, another book on the subject? There are probably two reasons. The first is that technical writing falls into many different categories; the writer who has concentrated on handbooks, say, will need to readjust his thinking and technique if he is successfully to draw up an article for a house journal, or a report to management. A handy work of reference—which this book is—outlining the general requirements in the various fields of technical writing under clear headings and sub-headings, can then be more useful than a comprehensive book of study. The second reason is that much more attention is being given to functional English in the training of the modern engineer as a necessary part of his tool kit. The practising engineer who had none of this in his training will soon be forced to improve his own writing techniques if he is to hold his own against newcomers, and a short, clear to-the-point guide adequate to his needs will be of more use than larger works. Mr. Baker's book forms just such a short reference work, covering briefly communication, forms of technical writing, English composition and grammar, presentation, use of illustrations, reproduction methods, and economics.

Draughtsmen and illustrators will notice one serious error—an oblique drawing captioned "An isometric drawing". This rubs in two points made by the author: (a) that an illustration focuses attention; (b) that technical information must be thoroughly checked. Perhaps this error ultimately is a more useful lesson to the reader than if the caption had been correct!

P. J. Booker

OTHER BOOKS RECEIVED

Year Book and Technical Guide: 1960-61, of The Association of Supervising Electrical Engineers. (*Fraser Pearce Ltd.—5s.*)

The tenth edition has been re-edited to include new information, and now extends to 216 pages. New technical notes include information on metal rectifiers, control gear, fire hazards, oil burner controls and the installation of communal TV aerial systems.

The Sustained Load Strength of Timber. (*The Timber Development Association Ltd.—3s. 6d.*)

In this report timber is examined as a viscous-elastic material, and possible criteria for the onset of plastic flow investigated, with a suggested means of determining the sustained load strength.

Glass Fibre for Amateurs. *By G. M. Lewis and R. H. Warring.* (*Model Aeronautical Press Ltd.—7s. 6d.*)

This is essentially a book for the practical man, which will enable him to successfully extend the do-it-yourself technique to reinforced plastics. The raw materials are first discussed, and then the various means by which they may be fabricated. Numerous illustrations of a practical nature leave no doubt about the methods of procedure. A useful appendix includes the properties of various mixes, and the strength and sources of the materials.

Metal Industry Handbook and Directory: 1961. (*Iliffe Books Ltd.—21s.*)

In this, the fiftieth edition, revisions and additions have been made in order to bring the book completely up to date with current information.

British Plastics Year Book: 1961. (*Iliffe Books Ltd.—45s.*)

This carefully prepared and presented guide contains lists of materials, manufactured goods and equipment, together with tables giving the properties of plastics. A useful addition to this edition is a list of companies, giving their basic services in moulding, extruding, metallising and other processes.

Summary of Recommendations for Research and Development in Materials. (*PB. 161865, Office of Technical Services, U.S.A.—$1.50.*)

Consists of a review of the recommendations for research which have arisen from specific studies. Covers metals, ceramics, plastics and fabrics which are likely to be required to meet future demands.

Vacuum Brazing with Radio-frequency Induction Heater. (*H.M.S.O.—3s.*)

A study of brazing methods which preclude the use of fluxes or preliminary cleaning. Applications are also described to illustrate the scope of radio-frequency induction heating.

Alloy Steels. (*Samuel Fox & Co. Ltd.—£2 2s.*)

A comprehensive collection of technical data on alloy steels fulfilling the BS En series of specifications. These data include physical properties, as well as information for the metallurgist on the concepts of hardenability and transformation.

Handbook on Electroplating. *Supplement to the Nineteenth Edition.* (*W. Canning & Co.*)

This supplement is available free of charge to those possessing the nineteenth edition (reviewed in *E.M.D.*, July 1960). It contains recent developments and current modifications in processing and techniques.

An Atlas of Process Defects. *Plating Zinc Alloy Diecastings.* (*BNF development report—15s.*)

A distinctive illustrated booklet indicating the defect, cause and remedy as applied to the plating of zinc alloy die castings.

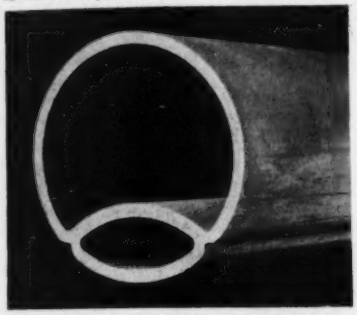
The Natural Resistance of Certain Timber Species to Marine Borers. (*The Timber Development Association Ltd.—3s. 6d.*)

The results of screening tests on twenty different timbers to determine their natural resistance to marine borers.

WHAT'S NEW IN MATERIALS

Integrally-traced Piping

Many commodities must be either heated or cooled to enable them to be piped, and this is usually done by running two pipes adjacent to each other, one pipe containing the product and the other (the trace pipe) the heating or cooling medium. Noraltrace, which is extruded from Noral 50SW aluminium alloy, incorporates both the product and trace lines in one compact pipe, and thus provides a neat, integrally-traced piping system. This strong, light, seamless pipe is extremely resistant to corrosion and



free of rust. It is claimed to have a low weight per foot, to offer low resistance to flow, and to require no protective maintenance such as painting.

Noraltrace has a high thermal efficiency, since the trace and product lines are in close contact with each other, and aluminium has excellent heat-transfer characteristics. It will fit standard preformed thermal insulation. For connection with vessels, valves, etc., special flanges are available. For long pipe runs, however, lengths may be simply butt-welded. The pipe can be easily bent in any direction using conventional bending equipment and standard size formers. *Alcan Industries Ltd.*, Banbury, Oxfordshire.

EMD 6989 for further information

Pipe Thread Seal

A new type of pipe jointing, Klingerflon Thread Seal, consisting of unsintered ribbon of p.t.f.e., is available for use as a sealing medium for threaded pipe fittings in ferrous or non-ferrous metals and plastics for the engineering, chemical and electrical industries. The sealing tape or cord is wrapped around the pipe, and is claimed to readily conform to the contours of the thread, producing a perfect seal which is resistant to all chemicals, solvents and oils. The seal's low friction coefficient of 0·04 enables one pipe to be readily screwed into another, and to be easily unscrewed after years of usage. *Richard Klinger Ltd.*, Sidcup, Kent.

EMD 6990 for further information

New Electrical Tapes

For some months a translucent grade of Transonex polyester thermosetting tape has been available, but it has been realised that many applications require a high-temperature tape of distinctive colour. To meet these needs, a yellow grade of Transonex tape, which has excellent solvent resistance and which is free from staining tendencies, has been introduced. After curing, this tape will operate in temperatures up to 180 deg. C., and has a breakdown voltage of 5,000 volts. A high degree of solvent resistance may be obtained by curing at 150 deg. C. for 1 hr., or 120 deg. C. for 2 hr. Maximum solvent resistance is achieved by curing for double these periods.

Another addition to this firm's technical range is cellulose acetate electrical tape. This is based on a specially flexible pure grade of transparent cellulose acetate film, and has a key-coated electrical-grade adhesive with freedom from corrosive tendencies. These properties make it suitable for use in the manufacture of small coils constructed of fine copper wires, where thinness and high insulation resistance are also required. With an upper working temperature of 130 deg. C. for several hours (without passage of electricity) this tape is claimed to withstand many of the drying-out procedures employed by the electronics industry in coil manufacture. *John Gosheron & Co. Ltd.*, The Packaging and Industrial Tape Centre, Albert Embankment, Vauxhall, London, S.E.11.

EMD 6991 for further information

Light, Flexible Delivery Hose

Drakeline is a delivery hose for oil products, claimed to be lighter in weight and more flexible than any previously marketed. The smooth inner bore consists of a thin seamless tube of a carefully blended oil-resisting rubber compound. Mechanical strength to support hydraulic forces is derived from a scientifically designed circular woven reinforcement carcase of nylon/terylene, embracing great strength with low bulk, and free entirely from the weakening effects of mildew.

The external carcase is thoroughly impregnated and coated with a tough oil-resistant olive-green plastics, imparting a substantial and proven wear resistance, and presenting an easy-to-handle external surface which is resistant to oil and grease contamination, and readily cleaned.

Drakeline is said to be the ideal hose for arranging immediate delivery facilities in situations where no permanent delivery lines exist. It can be used also for temporary or emergency mud lines in drilling operations. *George Angus & Co. Ltd.*, P.O. Box 139, Angus House, 148-158 Westgate Road, Newcastle upon Tyne, 1.

EMD 6992 for further information

New Ice-proof Adhesive

Chemtite is a new adhesive which is unaffected by sudden temperature changes, and which is claimed to withstand immersion in ice or iced water for a week without any detrimental effects. This new gum does not drip or string, and spreads evenly. Only a thin film is needed to achieve firm bonding to hot or cold, wet or greasy bottles, opal jars, internally siliconed vials and sand-blasted bottles. The dried film does not crystallise, and is said to withstand temperatures up to 149 deg. C.

Due to its temperature resistance and good bonding qualities, Chemtite can be used for labelling potentially dangerous chemicals such as drugs or poisons, and for antibiotics in deep-freeze. In particular, it is a protection against the unauthorized removal of labels for re-sticking on other containers. *National Adhesives Ltd.*, Slough, Bucks.

EMD 6993 for further information

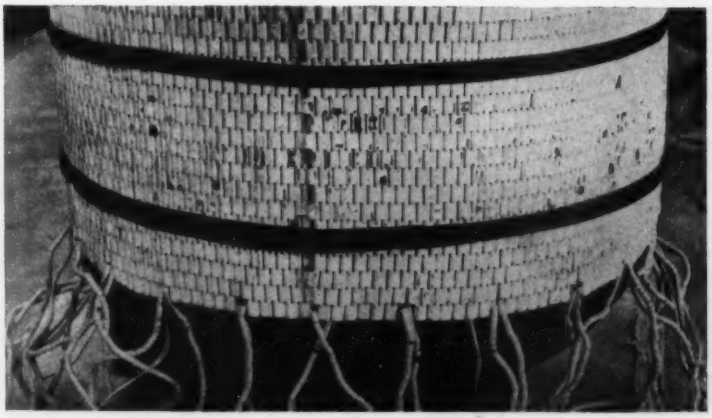
Flexible-surface Heater

The modular flexible furnace provides "off-the-shelf" heating up to 1,000 deg. C.; custom-built units are also available with temperatures up to 1,500 deg. C.

The excellent properties of modern industrial ceramics have been used to full advantage in the design of these heaters. Ceramic blocks and beads ingeniously interlocked about the element wires form a flexible mat of considerable mechanical strength. Maximum heat transfer coupled with effective electrical insulation is ensured. Standard and custom-built modular units which can be easily linked together with metal links are available.

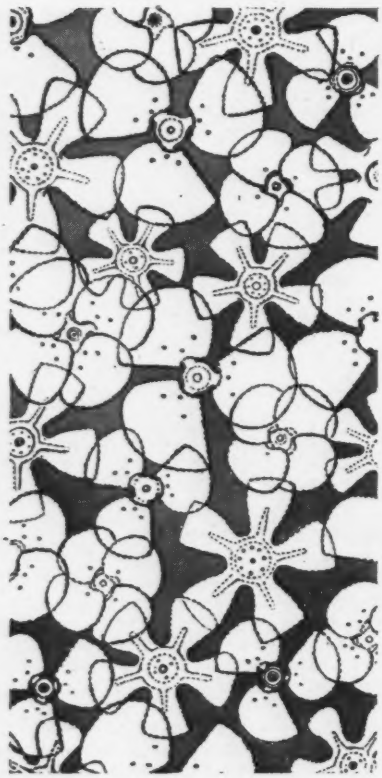
Applications of the heaters include: heat-treatment processes; stress relieving; preheating for welding; baking-out processes in vacuum; and machinery and platen heating. *Electrothermal Engineering Ltd.*, 270 Neville Road, London, E.7.

EMD 6994 for further information



EMD 6928 for further information

PROPELLER FANS?
YES, SIR!
BIGGEST RANGE
IN THE COUNTRY

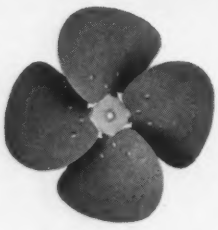


AIROTORS?
YES, SIR!
BIGGEST RANGE
IN THE COUNTRY

BOFFINS?
YES, SIR!
BIGGEST BRAINS
IN THE COUNTRY

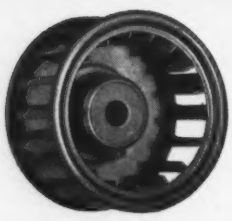
The world-famous TORRINGTON air-impellers are now made and sold by SMITHS.
SMITHS offer the widest range of airotors and propeller fans in this country, and can assemble and deliver promptly from a wide range of tooled stock components.
SMITHS Technical Advisory Service puts at your disposal the unrivalled knowledge and experience of both great organisations.

SMITHS
TORRINGTON
AIR IMPELLERS



PROPELLER FANS

From 3″ to 24″ diameter, either rotation, in a variety of pitches. Light, rigid, quiet, efficient.



AIROTORS

From 1½″ to 11″ diameter, available in steel or aluminium. In widths from ⅝″ to 11″.

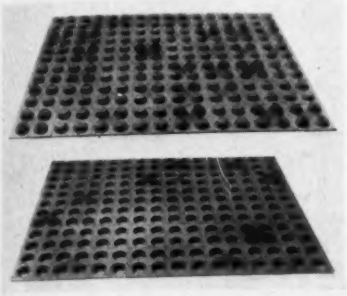
Write to SMITHS for illustrated literature and technical information. SMITHS engineers will be particularly interested in helping to develop new air-moving applications.

S. SMITH & SONS (ENGLAND) LIMITED, AIR IMPELLER DEPARTMENT, WITNEY, OXON. TELEPHONE: WITNEY 678

WHAT'S NEW IN MATERIALS

Moulded Prefabricated Ducting

A prefabricated ducting is now in production as a wood fibre moulding. Although at present only tooled up in a small section (four cones), any number of these can be riveted or stapled together for experimental or even production purposes. The mouldings, which are known as Coneplast, are illustrated in the accompanying photograph made up in a size 6 × 8 ft.



Coneplast can be used as multi-directional ducting for floors, walls or ceilings. Two mouldings joined dome to dome provide 3 in. hexagonal ducts, and can therefore accommodate all services, i.e. electrics, water, gas and air.

When sheeted with hardboard or plasterboard, a complete ducted partition is formed having the unique facility of service connections at all points throughout the entire surface area of both sides of the partition. It is also suitable for light load-bearing ducted ceilings.

The Coneplast panels can also be used as shuttering for concrete walls, to achieve ducting or decorative walling—either concave or convex. In the existing size the mouldings cost 1s. per sq. ft.; when the larger sizes are tooled up, this price should drop to 9d. per sq. ft. *Prestfibre Ltd.*, Spencers Wood, Reading.

EMD 6995 for further information

Reinforced Transparent Acetate Sheeting

Claritex is a recently developed material manufactured from a special grade of the Clarifoil transparent acetate film. Cellulose acetate film has a high reputation for its light transmission and toughness, and the addition of a wire reinforcement gives Claritex even more rigidity and dimensional stability, making it virtually unbreakable. This combination of properties, and its many other advantages, makes the sheeting suitable for glazing frame lights, sheds and other outbuildings.

Claritex is available in standard 100 ft. rolls, 2 ft. wide with 1 in. and 2 in. square mesh; in addition to this size, 48 × 20 in. and 51 × 24 in. sheeting in thicknesses ranging from 20 thou. to 3 mm. can be supplied. It weighs only 24 oz. per sq. yd. *British Celanese Ltd.*, Celanese House, Hanover Square, London, W.1.

EMD 6996 for further information

New Spring Material

Mallory 53 is a nickel-silicon-copper alloy that is claimed to fulfil the need for a new spring material having mechanical properties at least equal to those of conventional phosphor bronzes and brasses, but with appreciably higher electrical conductivity. This alloy should prove of interest to designers of electrical equipment, especially those involved in the production of miniaturised components.

One advantage derived from the use of Mallory 53 is that owing to its high electrical conductivity, 40-45 per cent I.A.C.S., it is possible for springs of small section to carry appreciably larger currents when made in this new alloy than when made in phosphor bronze. In addition, it is said that all spring-forming operations can be applied after heat-treatment, and hence the alloy is supplied in the precipitation hardened condition, requiring no further heat treatment by the user.

A provisional electrical engineering data sheet, giving details of the properties of Mallory 53 and the forms in which it can be supplied, is now available. *Johnson, Matthey & Co. Ltd.*, 73-83 Hatton Garden, London, E.C.1.

EMD 6997 for further information

Small-bore Glass Fibre Tubing

Small-bore glass fibre tubing in long lengths is now available, made by a patent continuous process in ¼, ⅜ and ½ in. i.d., with a $\frac{1}{16}$ in. wall thickness. The tubing is said to be practically chemically inert, and broadly speaking to be waterproof, corrosion-resistant and shatter-proof.

The ¼ in. i.d. tubing shown in the accompanying photograph is 35 ft. long and coiled in a 6 ft. dia. circle. For ease of transportation, it is normally supplied in 10 to 20 ft. lengths. When experimental work is completed, larger sizes will also be available. *Fibre-glass Tubes (Isle of Man) Ltd.*, Kensington House, Rosemount, Douglas, Isle of Man.

EMD 6998 for further information

Metallised Polyester Tape

A mirror-like surface has been produced on a new pressure-sensitive tape in the Sellotape range by coating polyester film with a heavy deposit of aluminium. An obvious use for this metallised polyester tape is as a surfacing medium, since it provides an economical easy-to-apply substitute for chromium plating. It can be used as a decorative trim to panels, and possesses excellent light reflecting properties which make it suitable for use on lighting fixtures and appliances.

The tape will adhere to almost any flat or curved surface, including metal, plastics, glass or chromium plating. In addition, it will withstand exposure out of doors for six months or more—even in the most adverse weather conditions. It has a high degree of chemical resistance, and is available on 72-yd. rolls in widths from ¼ to 2 in. *Gordon & Gotch (Sellotape) Ltd.*, Publicity Department, 8-10 Paul Street, London, E.C.2.

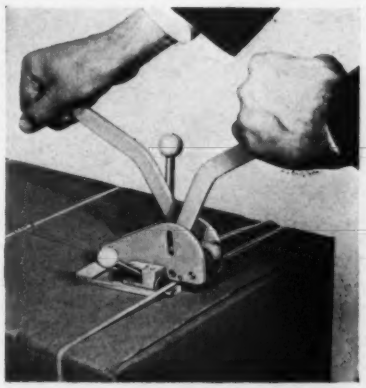
EMD 6999 for further information

New High-strength Non-metallic Strapping Tape, and Tensioning Tools

Experience with Quikstrap strapping tape has shown that while it has proved suitable for cartons and containers of medium weight, a need exists for a much stronger strapping tape for heavier weights, and for palletising, pressure baling, and bundling for round packages such as plastics and metal tubes and other irregularly shaped articles. A new strapping tape of high tensile strength has therefore been developed. It is anticipated that this new product, which is called Tufstrap, will be a serious challenge to steel as an alternative method for strapping, because of its toughness, high breaking strength and resistance to shock loads. It is available in two widths, ½ and ¾ in., other widths up to 1 in. are to follow shortly.

New tensioning tools have been designed, a special feature of these being the tensioning unit—this is a ratchet-operated split shaft which permits maximum tension without the possibility of scuffing damage. The operation of the sealing jaws also activates the cutter blade, which is spring loaded for return action after the strapping operation is completed. The tools are colour coded for identification. (The model illustrated is designed for ½-in. Tufstrap.) An improved floor dispenser is available for ease of application. *P. P. Payne & Sons Ltd.*, Haydn Road, Nottingham.

EMD 7000 for further information



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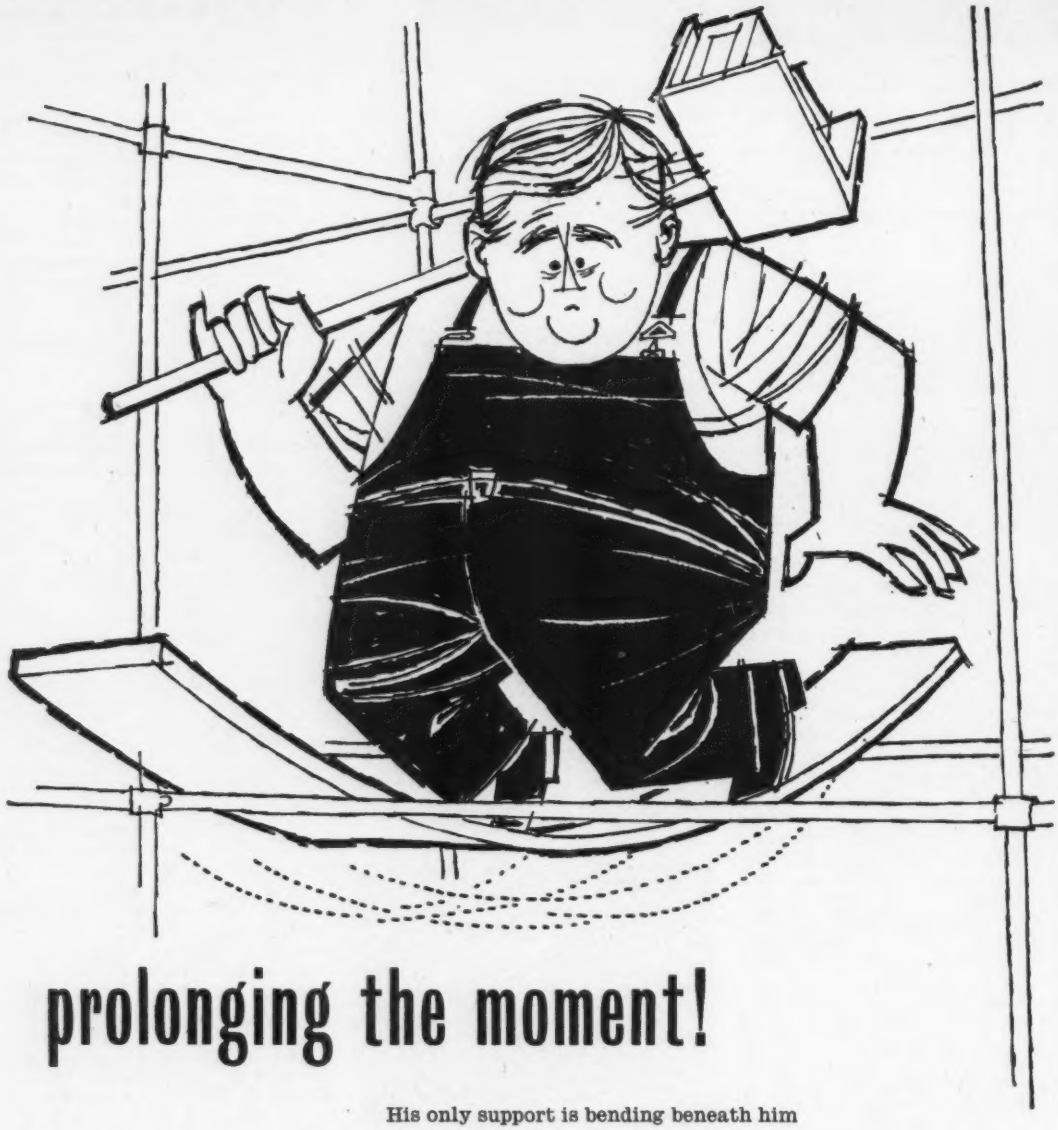

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WHAT'S NEW IN COMPONENTS

Miniature D.c. Relay

A new miniature relay, the B.14, measures 1 x $\frac{11}{16}$ x $1\frac{5}{32}$ in., and weighs only 1 oz. It has a maximum of one changeover silver or silver cadmium oxide contact, and the common contact is connected to the relay frame. The contact gap is 0·015 in., and the contact pressure 8 gm. minimum. Nominal operating power is 100 milliwatts, although the relay will operate at 80 per cent of this figure. The operating time at maximum power is 3 milliseconds. *B. & R. Relays Ltd.*, Temple Fields, Harlow, Essex.

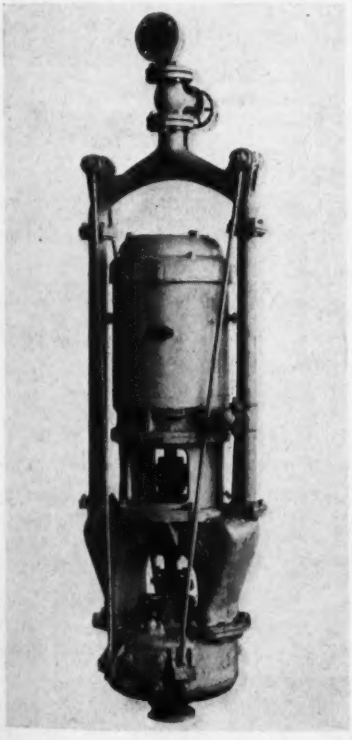
EMD 7001 for further information

Vertical Self-priming Pumps

New versions of a range of electrically operated vertical spindle self-priming pumps, for sub-level operation, include improved impeller design and an extensive use of spheroidal graphite iron to eliminate electrolytic effects arising from the use of dissimilar metals for such parts as impellers and wearing plates.

The range, which includes units of 2, 3, 4 and 6 in., suction and delivery, meets a particular demand where it is necessary to keep a sub-level working floor as free as possible of equipment. Thus by mounting the pump at some distance above the floor level, ample headroom can be obtained while retaining the self-priming characteristic of a high-capacity, high-lift pump, leaving only a suction hose to sump which may be flexible and light to manœuvre to any required position.

In these pumps, a totally enclosed fan-cooled, weatherproof, high-starting-torque, low-starting-current induction motor, operating on 400/400 volts, 3 phase, 50 c/s supply, is direct coupled to the vertical spindle of a self-priming pump, the self-priming effect being achieved by the recirculation method. The unit is slung in a cradle formed by the twin delivery branches of the pump which unite above the motor in a flanged Y piece to which may be fitted a gate valve. The pump impeller is of the open type, allowing the passage of slurries of high solids content, and the volute is fitted with renewable wearing plates. The shaft is fitted with a renewable hardened sleeve, and is carried in large-diameter ball races. *Henry Sykes Ltd.*, 53b Southwark Street, London, S.E.1.



EMD 7002 for further information

Elapsed Time Indicators

A new range of electro-mechanical elapsed time indicators weigh only about $1\frac{1}{4}$ oz. each. These miniature "electro clocks" record the precise operating time

of electronic equipment and instrument systems, and are said to be ideal for airborne systems and missile ground support applications.

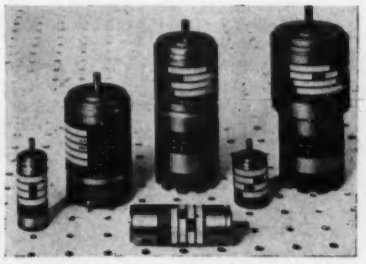
The indicators have either a dial or digital read-out, and will record up to 1,000 hr., though units for other time ranges are available. They are of cylindrical shape, with a diameter of 0·680 in. and a length of 1·42 in. (dial type) or 1·76 in. (digital type). Operation is by a synchronous electric motor and gear train available for single-phase 400 c/s, 115 volt or 26 volt; there is also a 28-volt d.c. model. Power consumption is 1 watt. The units are filled with an inert atmosphere to prevent deterioration by moisture, and are hermetically sealed. All coils are encapsulated in epoxy resin for total protection, and no shorting to earth occurs under operation within the specification conditions. The dial type is fitted with white hands and a black dial-face, and is readable to within 0·1 per cent. *Aeromaritime Ltd.*, 45 Ladbroke Square, London, W.11.

EMD 7003 for further information

Precision Electro-mechanical Components at High Temperatures

With the increase of control systems on modern high-speed aircraft, precision electro-mechanical devices are required to operate continuously at higher and higher temperatures. A recent demonstration showed a simple positioning servo system consisting of an actuator unit, in an ambient temperature of 200 deg. C., driving a variable load. The load consisted of a 4-lb. steel ball on a $7\frac{1}{2}$-in. arm giving a maximum torque of 30 lb. in.

The actuator unit itself incorporates a special high-temperature International Frame Size 18, two-phase, 400 c/s servo motor, and a Size 11 resolver for positioning control. The gear reduction is 420:1 and the whole unit is flood lubricated. Units can also include a d.c. motor, which can be brought into operation through a differential unit in case of a.c.



supply failure. The motor can also be supplied with an integral tachogenerator for velocity feed back. Similar units have successfully completed endurance tests of more than 1,000 hr. *Vactric (Control Equipment) Ltd.*, Vactric House, Sloane Street, London, S.W.1.

EMD 7004 for further information

Miniature Mineral-insulated Thermocouples

A new process has been developed for the production of earthed and insulated hot junctions in mineral insulated thermocouple cables. Thermocouples are now available with sealed earthed junctions in cable sizes down to a diameter of 0·01 in. Insulated and sealed hot junctions can be produced in cables down to 0·02 in. dia. at present, but developments should extend the range down to 0·013 in. dia. in the near future.

The process depends essentially on a new welding technique developed from the standard Spembly capacitor discharge welding equipment. Basically, capacitors are charged to the correct voltage to cater for length and conductor resistance. They are then discharged through argon, which has been ionised by a high frequency field, to form the insulated hot junction down inside the cable end. The thermocouple is also capped by a similar process, which produces a vacuum-tight weld with no increase in the overall diameter of the cable.

The whole welding process is automatic. *Spembly Ltd.*, Chatham, Kent.

EMD 7005 for further information

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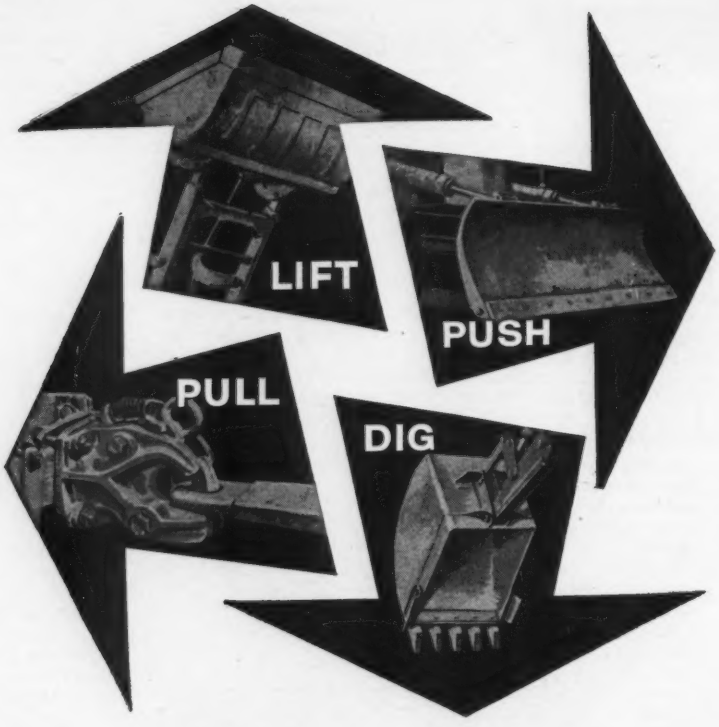

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6th Gear	1.04 : 1	2.53 : 1
Low Rev	4.90 : 1	6.30 : 1
High Rev	2.73 : 1	18.70 : 1
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WHAT'S NEW IN COMPONENTS

Vibration Accelerometer

A new accelerator, type G 170, designed for vibration tests in a wide range of applications, is said to have particular uses in the aircraft and automotive industries, and in the development of shock-proof packaging techniques. A special feature is its light weight of 5 gm., which enables it to be used for testing component parts as well as complete assemblies. It is only ¼ in. long and ½ in. dia., and is fitted with a sub-miniature coaxial connector.

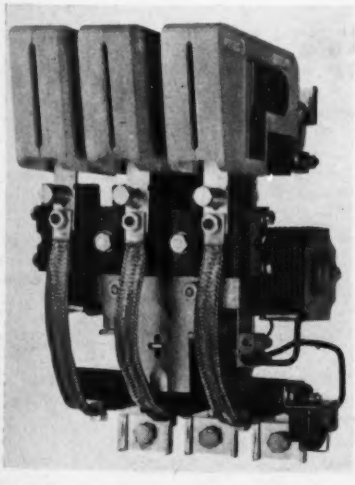
The G 170 is claimed to operate over a frequency range from 5 to 3·5 kc/s, and to measure shock and vibration in the range 0·1 to 400 g. Operating temperature limits are −40 to +80 deg. C., and the units are fully sealed to withstand conditions of high humidity. A bender-type transducer gives maximum sensitivity in a coaxial direction with minimum sensitivity in other directions. A high self-capacitance has been achieved, which enables measurements to be made at low frequencies using a cathode follower unit. *Technical Ceramics Ltd.*, Wood Burcote Way, Towcester, Northants.

EMD 7006 for further information

New Unit Contactors

The H series of unit contactors are available in 50, 100 and 200 amp. versions for a.c. or d.c. working. Each version can be supplied as a single- or multi-pole unit. The construction allows additional poles to be added (within each version) to a single pole unit, without changing the coil.

The unit mounting and front wiring of these contactors facilitates installation and maintenance, as does the single screw fixing of the coil and contacts. All units are claimed to be exceptionally quiet in operation. Rated to BS 775 (A4 or D4)



and having full C.S.A. approval, they are short circuit tested at 31 MVA. against their respective HRC fuse ratings.

A unique blow-out system incorporating separate tungsten arcing contacts obviates derating, and ensures long operating life. Extras available include auxiliary contact assemblies and damp and dust protecting or weatherproof case. Intended for heavy duty in any climatic conditions, these contactors are claimed to be the most competitively priced available. *Dewhurst & Partner Ltd.*, Inverness Works, Hounslow, Middlesex.

EMD 7007 for further information

Annunciator Units

Most industrial processes require a warning to be given if one or more variables such as pressure, level or temperature rise or fall below a pre-set value. For this purpose units such as pressure and level switches, etc., are provided which operate their contacts when a danger condition is reached. The SIG/O

and SIG/C Annunciator units have been designed to operate in conjunction with any of these contact devices. The SIG/O unit is for use with initiating contacts which close, and the SIG/C for contacts which open on alarm condition.

The units are completely self-contained, and incorporate a red and green warning lamp, as well as output contacts for controlling an audible alarm. When the initiating contact is in its normal condition the green lamp on the annunciator unit is illuminated. When the initiating contact operates, the green lamp extinguishes, the red lamp illuminates, and at the same time the alarm relay contact within the unit closes to control an audible warning.

On pressing the cancel button the alarm relay contacts reopen, thus silencing the audible warning, but the red lamp remains illuminated, giving visual indication that the danger condition still exists. The red lamp remains illuminated until the initiating contact resets.

An additional feature incorporated in these annunciator units is a Test/Normal switch, enabling an alarm condition to be simulated at any time for test purposes. *Londex Ltd.*, Anerley Works, London, S.E.20.

EMD 7008 for further information

High-speed Visual Decade Counting Units

The Winston visual decade counting units count impulses up to a maximum rate of 40,000 per sec. Each unit has a scale which indicates the counts from 0 to 9. The tenth impulse resets the unit to zero and simultaneously generates an output pulse which is fed into an adjacent unit which then counts the tens from 10 to 90. When the two units show 99, the combined output pulse is fed into the third unit for the 100 to 900. It is possible to count any number of digits, the limiting factor being the number of decade units used in cascade.

The unit may be used for counting pulses in any form of electronic counter. The field of applications includes packaging, machinery, mass-produced outputs for both the end product and the intermediate process stages, machine shops, pressing shops and the counting of measuring units. *Winston Electronics Ltd.*, Shepperton, Middlesex.

EMD 7009 for further information

Hetropolar Motor

The Nelson Hetropolar motor is available from 60 to 600 oz. in. for 1, 2 or 3 phase operating, and permits a single or multiple indexing movement to be obtained electrically. Its use eliminates the risk of "gear lash", providing a true speed of 62·5/75 93·75 r.p.m. at 50 c/s or 75/90 112·5 r.p.m. at 60 c/s by direct drive. The power-to-dimension ratio is favourable, torque output is constant, and stopping, starting or reversal is almost instantaneous (full synchronous speed is reached immediately). During operation, the locked rotor current does not exceed the full load; the motor, therefore, cannot burn out and is suitable for continuous duty.

Maintenance is reduced to a minimum, since there is only one slow-moving part and bearing wear is negligible. The motor is self-starting (direct switch) and can be used with any a.c. voltage (suitable low-voltage transformers can be supplied). It is said to have been successfully applied, in single indexing, for the accurate control of continuous band cutting by guillotine or diamond knife; fluid ejection; particle separation by valves; and liquid intake by metering pumps. *The Nelson Engineering Co. Ltd.*, Netherfield Works, Nelson, Lancs.

EMD 7010 for further information

Plastics Hand Pump

A hand-operated pump constructed of corrosion-resistant plastics is now available. It has a bore of 1¼ in., and is capable of discharging 3 gal. of water

per min. with a stroke length of 12 in. It has an overall length of 21 in. closed and 31 in. when open, and is normally fitted with adaptors to take a ¾-in hose. *Barflo Ltd.*, 56 Cavendish Place, Eastbourne. **EMD 7011** for further information

WHAT'S NEW IN COMPONENTS

New Centrifugal Pumps

The GGG series of heavy-duty self-priming pumps has now been supplemented by the new Centuri range of end-suction spigot-mounted centrifugal pumps, for duties in which the self-priming feature and high delivery head are not required. In this range a robust heavy-duty construction is employed, pump and motor being combined to form one unit occupying a minimum of space. The through-spigot assembly ensures that perfect alignment is always maintained, and a single shaft carries the motor rotor and pump impeller.

Standard units can operate in any position from horizontal to the vertical. Delivery branches can be arranged in four alternative positions. The range of sizes covers a capacity of up to 500 gal./min. at heads up to 230 ft.; pipe connections from 1 to 3 in.

The impellers are of the gunmetal single-suction enclosed pattern, hydraulically and mechanically balanced. Renewable bronze wear rings seal the impeller hubs and protect the impeller casing. Mechanical seals, with carbon/stellited-stainless steel faces are provided. Special units of all-iron, bronze and other materials can be supplied where the liquid to be pumped requires it.

Standard pumps are based upon British Standards totally-enclosed a.c. motors; drip-proof, flameproof and d.c. marine pattern motors are also available. *Gilbert Gilkes & Gordon Ltd.*, Kendal, Westmorland.

EMD 7012 for further information

Special Hydraulic Equipment

While there exists a wide range of standard proprietary hydraulic pumps, valves and other equipment available "off

the shelf", there are many occasions when to use standard components results in a complicated, bulky or expensive layout. Purpose-designed units are now obtainable for such applications. The accompanying photograph shows a typical unit —this combines the functions of two pumps and three valves in a single casing, with only four pipe connections to make.

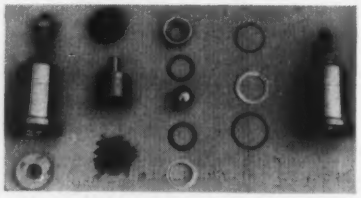
The unit consists of a variable delivery pump with a micrometer thimble control knob, a volume pump for rapid motion, a three-way valve to control the volume pump, a four-way valve to control the direction of travel, and an overload relief valve.

Similar units have been produced with two variable delivery pumps. These can be arranged to deliver different fluids from each line for blending and similar purposes, and coupled controls can be fitted. Multi-element valves can be produced combining such functions as relief, flow, limit and directional control in a single unit. *Control Developments Ltd.*, 30 Gloucester Street, Gorton, Manchester, 18.

EMD 7013 for further information

Conveyor Ball Transfer Unit

The accompanying photograph gives details of a 1-ton capacity Omni-Track unit in the housing employing Belleville washers giving a pre-stressed loading of 750 lb. Any pressure applied above this load automatically depresses the O.T. within the housing so that the ball becomes flush with the top face. This article was specifically designed for use in front of a guillotine blade, so that when heavy sheet is pushed over a number of these O.T.s in a position for shearing they depress when shearing takes place. When the blade returns, the plate



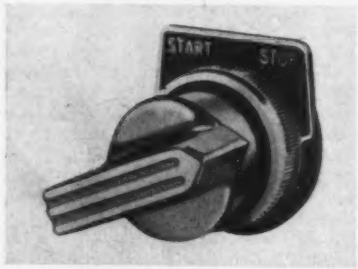
is automatically raised to the pre-stressed condition so that the operator can readily move the heavy sheet to one side.

Another model employs a standard 1-ton capacity O.T. mounted in a cylindrical housing 4 in. dia. with a wall thickness of $\frac{1}{4}$ in. The cavity between the walls and the O.T. housing can accomomdate a helical compression spring or, of course, rubber in compression, thus affording shock absorption or a condition of pre-stressing, whichever the customer requires. *Autoset (Production) Ltd.*, 69-73 Stour Street, Birmingham, 18.

EMD 7014 for further information

Oil-tight Selector Switch

The Class 9001 Type TS control unit is an oil-tight selector switch equipped with an operator, the physical dimen-

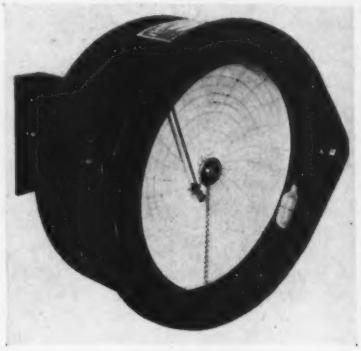


sions of which allows easy operation by personnel wearing gloves. The knob is chrome plated for eye appeal. *Square D Ltd.*, Cheney Manor, Swindon, Wilts.

EMD 7015 for further information

Wall-mounted Pressure Recorder

The Arkon model 60 pressure recorder is now available for wall mounting. Of sturdy construction, the recorder is driven either by a spring-wound clock or electric motor. It has an 8 in. dia. chart with 24-hr. or 7-day rotation, and is available



for a wide variety of ranges from 5 to 500 p.s.i. It is suitable for the measurement of gas, air, steam, water, oil and similar liquids.

The recorder has a dust- and moisture-proof glazed door fitted with an integral lock, and the chart record is visible at all times. There is also a portable version available fitted with a handle and stand, its total weight being only 9½ lb. *Walker, Crosweller & Co. Ltd.*, Cheltenham.

EMD 7016 for further information

Compact Mechanical Seal for High-speed Shafts

For high-speed shaft sealing applications where axial space is at a premium, a new mechanical seal, the type DD, has been developed. This new seal is said to cope with peripheral speeds up to 15,000 ft./min., pressures up to 1,000 p.s.i.g. and temperatures up to 260 deg. C. All the components are replaceable, and worn parts can either be replaced completely or reconditioned without destroying the whole seal. In addition, the overall length can be specified to close tolerances. The complete seal unit is designed as a press fit in its housing, and the smooth, clean profile of the outside diameter and rubbing faces is said to ensure accurate leak-free fitting.

The DD is a face-type balanced mechanical seal of multi-spring design, and consists essentially of a housing which carries a resiliently mounted stationary rubbing face assembly consisting of a body, an insert, and a resilient packing. Face loading is provided by a number of small springs arranged around the flange of the stationary seal ring body. This ensures close control and uniform application of the face contact pressure.

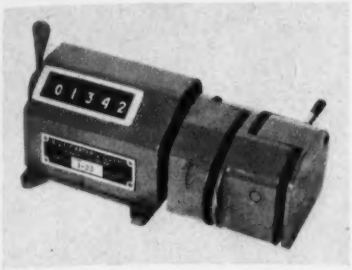
Three variants of the basic design are available: O-ring fitted; chevron packed; and "reverse balanced", respectively. In addition, each basic type is available in two ranges of axial tolerance and three face loadings. The standard range of sizes covers shaft diameters from ¼ to 8 in. *Flexibox Ltd.*, Nash Road, Trafford Park, Manchester, 17.

EMD 7017 for further information

WHAT'S NEW IN COMPONENTS

Counter and Gearbox

The illustration shows the new Albion type 1-23 revolution counter with



separate detachable gearbox, supplied right or left hand, with four or five figures and reset lever. The three-part box is shown opened up. A variety of ratios can be supplied to suit individual requirements.

Driving shafts may be at sides, front, base or rear (as illustrated). The unit can be supplied with or without gearbox. It includes a patented roller reset cam mechanism, and is self-lubricating. *B. & F. Carter & Co. Ltd.*, Albion Works, Bolton.

EMD 7018 for further information

20-millionths Ball Bearings

Ball bearings are now being produced with fourteen tolerances reduced to 20 millionths of an inch—a considerable advance in accuracy on anything previously achieved in this field. The bearings have been perfected, and are currently produced by the Barden Corp., of Conn., U.S.A., whose knowledge is now available to industrialists in Britain and on the Continent through Barden's European associates.

Each bearing is fully documented. All inner and outer rings are numbered serially, as are the bearings assembled from these parts. When shipped, each bearing is accompanied by documented evidence of compliance with dimensional and functional specifications. A tally sheet, backed up by gauge traces, shows the actual dimensions of the inner and outer ring of each bearing—all accurate to within 20 millionths of an inch. Prototype quantities of angular contact bearings are now available. *E.M.O. Instrumentation Ltd.*, Western Road, Bracknell, Berks.

EMD 7019 for further information

Air Valve for Heavy Load Deceleration

The T.A.L. Speedmaster is a sequence-controlled interlocked unit developed to make possible the fast movement of heavy loads. It is claimed to make possible the movement of loads of 1 ton or more over a distance of 4 ft. almost instantaneously at speeds in excess of 2 ft./sec., yet causing the load to come to a halt so gently that no damage is caused to the load itself or to the machinery on which the unit is installed.

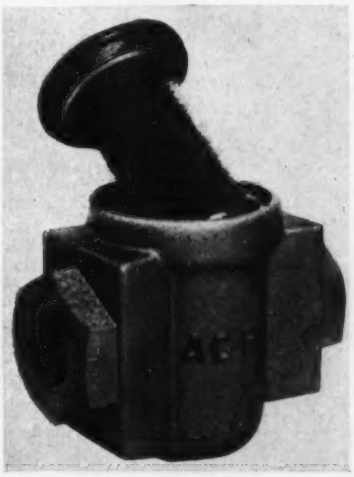
The Speedmaster is usually supplied as an electro-magnetic unit. Where it is dangerous or undesirable to use electric control, the unit can be supplied as a pneumatic unit throughout. There are said to be no limitations to the industrial applications of the Speedmaster, and it is recommended for the movement of heavy loads over distances of 3 ft. or more. The actuating cylinder can be either vertical or horizontal.

Two types are available—the Mark 1 is for the movement of loads between two predetermined and pre-set positions; the Mark 2 incorporates, in addition, a feature for arresting the movement of the load at any point between the two pre-set end positions. *T.A.L. Pneumatics Ltd.*, Leighton Buzzard, Beds.

EMD 7020 for further information

"Hedgehog" Filter

The Arlon-Hedgehog is a drum-type micro-filter using a cylindrical magnet and a corona of fine steel spines to catch



particles not normally stopped by standard filter materials or methods. These filters are manufactured for all flow rates up to 130,000 imperial gal./hr. Pressure loss in the units is said to be negligible, thus permitting their installation in suction lines. The magnetised steel spines catch ultra-fine particles with a dual action. *Ashton Wills (Filter Materials) Ltd.*, 3 Nursery Lane, Sheffield, 3.

EMD 7021 for further information

New Design Gear Pump

A gear-within-gear principle has been chosen for the Menrow pump, which can be contained within a small compass, and which has a capacity high in relation to its size (a 100 gal./hr. pump can be made as small as 4 × 3 in. dia.). Its versatility is associated with the fact that the fundamental principle can be easily adapted for project engineering necessities.

It is a positive pump with a suction lift of 25 ft. The basic pumping unit can be arranged so that flow can be in one direction with fixed rotation, or in one direction irrespective of pump rotation, or as a reversible type for direction of flow towards either of the two ports. The suction and delivery can be arranged upright, horizontally opposed, or at right angles. It is said to operate efficiently at any angle of mounting.

During the last five years it has been thoroughly field tested, and is already in use in various forms throughout the capacity range on packaged steam generators, diesel engines, oil burners, machine tools, oil tankers and refrigeration machinery. The range runs from 35 to 4,800 gal./hr., with pressures up to 650 p.s.i. *Mono Pumps Ltd.*, Mono House, Selsforde Street, London, E.C.1.

EMD 7022 for further information

Shaft-position Encoders

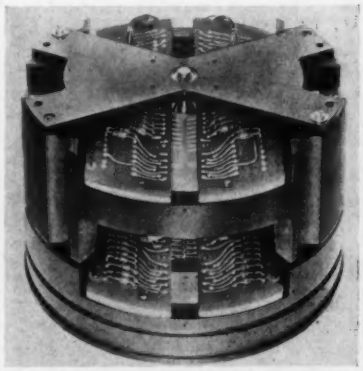
Recently introduced by the Norden Division of United Aircraft Corp., and now available in the U.K., is a new range of shaft position encoders. Applications for these devices embrace machine tool control, film readers and all types of navigation device, including those for the measurement of such variables as heading, bearing and azimuth.

Type ADC-36BCD provides 360 discrete counts per rotation of the input shaft, numerical indication of shaft position being given in degrees in 8-4-2-1 binary coded decimal code. Self-selecting V-brush logic is incorporated, so obviating the need for extensive external brush selection logic circuitry. The encoder is contained in a size 33 standard U.S. Bu-Ord synchro mount through the use of the split-bit technique.

Type ADC-5-BCD (1000) is capable of 100,000 counts in only 100 turns of the input shaft. Like the previous type, this uses a self-selecting V-brush logic, and the split bit technique again permits incorporation of this high-resolution encoder into the smallest container possible. It is basically a 1,000 count per turn device.

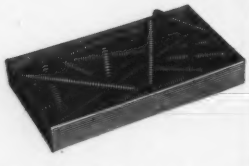
The third type, providing 1,024 counts per shaft rotation, is contained in a standard U.S. Bu-Ord size 33 synchro mount and gives an output in Gray Code. This device supplements the Ketay range of Gray Code encoders, which includes a size 18 providing 256 counts and a size 23 providing 512 counts per turn. *Ketay Ltd.*, Eddes House, Eastern Avenue West, Romford, Essex.

EMD 7023 for further information



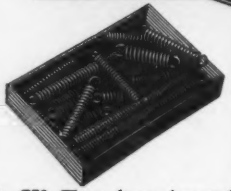
EMD 6931 for further information

EXPERIMENTAL SPRINGS?



No. 1200. Three dozen Assorted Light Expansion Springs, suitable for carburettor control, etc. **15/-.**

No. 98A. Three dozen Assorted 1″ to 4″ long, $\frac{1}{4}$″ to $\frac{3}{4}$″ diam., 19G to 15G. **6/6.**



No. 753. Three dozen Assorted Light Expansion $\frac{1}{4}$″ to $\frac{1}{2}$″ diam., 2″ to 6″ long, 22 to 18 S.W.G. **12/-.**

No. 760. Three dozen Assorted Light Compression Springs. 1″ to 4″ long, 22 to 18 S.W.G., $\frac{1}{4}$″ to $\frac{1}{2}$″ diam. **7/6.**

No. 757. Extra Light Compression, 1 gross Assorted, $\frac{1}{4}$″ to $\frac{7}{16}$″ diam., $\frac{1}{2}$″ to 2$\frac{1}{2}$″ long, 27 to 19 S.W.G. **18/-.**

No. 758. Fine Expansion Springs. 1 gross Assorted $\frac{1}{4}$″ to $\frac{3}{4}$″ diam., $\frac{1}{2}$″ to 2″ long, 27 to 20 S.W.G. **18/-.**

That spring you want . . . in a hurry . . . *where* is it? Pick *what* you want *when* you want it from TERRY'S BOXES OF ASSORTED SPRINGS—our fine range of small boxed assortments of experimental springs. We can show you only a few from the range here. Send a postcard for our full list—and if ever you're stuck with a spring problem send it along to our Research Department —they'll gladly help you out.

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MT31

WHAT'S NEW IN COMPONENTS

Double Pilot Valve

A four-way balanced poppet valve used in the control of double-acting air cylinders is said to be unique in being the only double-pilot, double-poppet type valve on the market. Reversal of the valve is by impulse of air applied to either pilot chamber. A very short pilot cylinder stroke is employed, together with a sliding metal-to-metal seal which makes the valve suitable for very high speed actuation with minimum maintenance.

The low pilot pressure of 15 p.s.i.g. and fast response of the air pressure controlled poppet openings is expected to make this valve popular in automatic circuitry and interlock controls. Two valve sizes are offered. No. 825P has ¼-in. B.S.P. ports and No. 826P has ⅜-in B.S.P. ports. Both valves are suitable for a pressure range of from 20 to 150 p.s.i.g. *A. Schrader's Son*, Division of Scovill Manufacturing Co., 829 Tyburn Road, Erdington, Birmingham, 24.

EMD 7024 for further information

Water Meter

The Type 44 water meter is claimed to be rugged but extremely accurate. This compact meter has been fully tested, and has recorded more than 5,000,000 gallons under difficult water conditions without maintenance and without loss of accuracy. All the components are made of materials selected specifically for their individual functions, and possess a combination of high mechanical strength with strong resistance to all forms of bacteriological and hygroscopic deterioration.

For instance, the measuring chamber is made of a precision moulded polyamide material which does not corrode and which inhibits deposition. The chamber is protected from the abrasive effects of foreign matter by means of a filter, designed to have a fine mesh and yet a large enough filtering area to minimise head-loss. All gears and pinions are made of a polyamide plastics, and their stainless steel spindles run in self-lubricating bearings.

Of particular interest to maintenance engineers is the two-part screwed gunmetal casing which, in conjunction with the absence of screws in the assembly of the Type 44 meter, means that components can be replaced if necessary without using tools of any kind. The use of gunmetal castings for the body gives maximum protection against corrosion by dezincification.

Available in the ¾ in. size with either wet or dry dial (the dry dial version being supplied with centre pointer or direct reading index), the new meter can handle without loss of accuracy flows of 400 gal./hr. at 10 ft. head-loss continuously for 24 hr. a day. At flow rates as low as 5 gal./hr. the accuracy is guaranteed to within ±2 per cent.

The Type 44 is hydrostatically tested to 300 p.s.i., and can sustain continuous working pressures of up to 150 p.s.i. *Parkinson Cowan, Roles & Parker Ltd.*, 22 Red Lion Street, London, W.C.1.

EMD 7025 for further information

Heavy-duty Stopwatch

A new precision 12-hr. stopwatch, specifically designed for panel-board and dash-board mounting, is announced. It

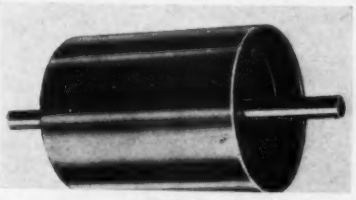
incorporates shock-resistant heavy-duty features (Incabloc jewel mountings, large solid crown, Plexiglas crystal, and heavy dust-proof housing specially plated for brine and sweat resistance) which qualify it for industrial, mining, over-the-road, aircraft, marine and test-bench service. The large jumping hour-disc, full-circle centre-shaft minute register, bold luminous markings on a non-reflective black face, and knurled turning bezel with large set mark, all make for easy visibility and fast reading.

For process and research instrumentation which require decimal data, an alternate dial face with extra peripheral divisions in hundredths of a minute is provided. *Baume & Co. Ltd.*, 50 Hatton Gardens, London, E.C.1.

EMD 7026 for further information

New Magnetic Separator incorporates Ceramic Magnet

The new range of Andox 5 permanent magnet pulleys are designed for extracting tramp iron from processed materials. The unit illustrated includes magnets made of the revolutionary anistropic barium ferrite ceramic material, of which the exceptional coercivity permits a radial pole construction as distinct from the



axial disposition adopted with Alcomax magnets.

The superior field intensities thus produced are equivalent to those of the electromagnetic designs, with flux distribution patterned to conform to the burden contour on the belt conveyor. Highest intensity occurs at the centre of the conveyor where burden depth is greatest.

Possessing unusual pulling and holding power, and using stainless-steel covers for long mechanical life, the pulleys are available in a range of sizes from 12 to 24 in. dia. for any belt width. *Rapid Magnetic Ltd.*, Lombard Street, Birmingham.

EMD 7027 for further information

Magnetic Level Indicator

The magnetic level indicator enables static storage tanks, road tankers and pressure vessels to be dipped from either the top or bottom without the need to be opened. Volatile, toxic, pressurised or valuable liquids may be checked without fear of danger, contamination or theft. Conservation valves can be fitted and evaporation losses minimised, since vapour is no longer lost during daily checks. The magnets are permanent.

Use of the indicator is restricted to a length of 12 ft., but within this length an accuracy of $\pm\frac{1}{32}$ in. can be expected irrespective of operator experience. Since the indicator is float operated, different readings will be obtained if used in liquids of different specific gravity. However, due to the use of a float of large surface area and small depth of flotation, the indicator can be zeroed over an s.g. range of 0·3 by the use of a simple adjustment. *Alan Cobham Engineering Ltd.*, Blandford, Dorset.

EMD 7028 for further information

Please Note!

We receive many reader enquiry cards on which the reader has omitted to fill in his name and address. In order to avoid disappointment we remind readers that names and addresses should be included on *each* card.

EMD 6932 for further information

MS FLUID FACTS

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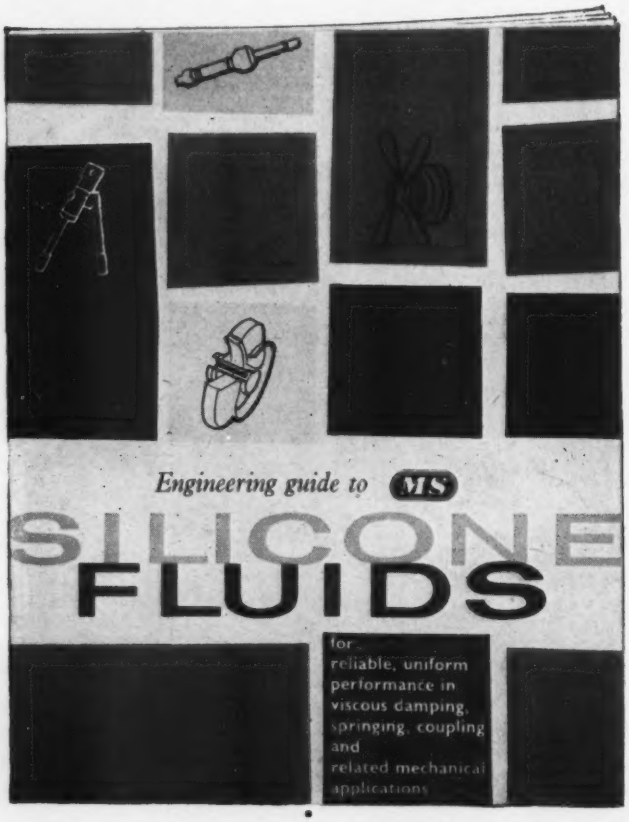
If your requirement is more for silicone lubricants and greases then 'Silicone Lubricating Fluids & Greases' (G 14) *is the publication for you.*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MSF8

WHAT'S NEW IN EQUIPMENT

Nylon Wheel Gravity Conveyor

With the introduction of the new Dexion Nylon Glidewheel, the Dexion conveyor system is said to be 20 per cent cheaper than with the steel glidewheel. The new glidewheel, graphite impregnated, needs no lubrication and runs smoothly and quietly even in damp or

corrosive conditions. There is no danger of dust clogging ball-bearings and, once installed, no further attention or maintenance is necessary.

The conveyors can be made to suit individual requirements, and the layout is easily modified or altered to keep up with changes in policy or working conditions. It is claimed that only the slightest gradients are required, and that no banking or guard-rails are needed at the curves. Used in conjunction with slotted angle for the framework and punched steel strap for the curves, the new glidewheel makes possible on-the-spot construction of conveyor systems, quickly and at low cost. *Dexion Ltd.*, Overseas Division, Beresford Avenue, Wembley, Middlesex.

EMD 7029 for further information

Non-destructive Materials Tester

A new non-destructive materials testing instrument, the Electrodynamic Materials Tester SCT4, covers a range from 100 to 10 kc/s with a calibration accuracy of ±0·1 per cent. It gives an accurate measurement of the resonant frequency of a regularly shaped specimen. From this reading and a knowledge of the dimensions and density of the sample, the elastic constants (Young's modulus, modulus of rigidity and Poisson's ratio) may be calculated. The measurement is, of course, non-destructive, and the effect of subsequent treatment of the material, such as irradiation in an atomic reactor, may readily be ascertained. *Cawkell Research & Electronics Ltd.*, Scotts Road, Southall, Middlesex.

EMD 7030 for further information

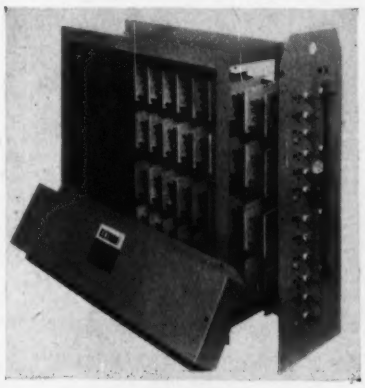
Metal-spraying Pistol

A new metal spraying pistol, the Berk Model 61, is said to be capable of spraying zinc at the rate of 110 lb./hr. with a high deposition efficiency, and aluminium and alloys at correspondingly high speeds. It is designed primarily for the spraying of large areas, and, in particular, for use where the heavy structural steel items and plates are to be metal sprayed after grit-blasting by automatic blasting machines. It is nevertheless light, flexible and economical in use, and, because of the absence of moving parts, requires little maintenance. *F. W. Berk & Co. Ltd.*, Coating Division, Brent Crescent, North Circular Road, London, N.W.10.

EMD 7031 for further information

Open Coil Air Heating Unit

A new design of open coil air heating unit has the elements spirally wound from 80/20 nickel chrome wire supported on natural grade sindanyo insulator bars. These bars are fitted to a mild steel frame on which the connections are mounted. This complete frame, with the elements and supports, is withdrawable from the steel duct casing without the necessity of breaking the duct joints, thus enabling the heating coils to be easily cleaned and renewed. A hand reset safety cut-out is fitted in each unit, and all the connections are protected by a sheet-metal cover. The units are made in sizes from



13 × 13 in. (having a loading of 3 kW.) to 30 × 30 in. (with a loading of 90 kW.).

This type of air heater is designed to operate at black heat, but it should not be used where the air contains free moisture, or where condensation occurs. Where the open wire construction is not suitable, the makers offer their standard type of units with black heat, sheathed-type elements. *Eltron (London) Ltd.*, Accrington Works, Strathmore Road, Croydon, Surrey.

EMD 7032 for further information

Pneumatic Roundness-measuring Instrument

This instrument measures the departures from circularity of workpieces to an overall accuracy of 0·00001 in. It has the following capacities: external dia., $\frac{1}{16}$ to 6 in.; internal dia., $\frac{1}{4}$ in. to 6 in.; and a maximum height of 6 in. A precision air bearing is used to provide an axis of rotation which is true to 0·00005 in.

An adjustable pneumatic measuring head, attached to the lower end of the shaft of the air bearing, detects the errors of the workpiece and records them on a circular chart rotating at the same speed (1 r.p.m.) as the measuring head. Magnifications of 1,000 and 5,000 are provided.

The advantage of an air bearing over a conventional plain bearing or a ball or roller bearing is that its accuracy of performance can be obtained without recourse to extreme accuracy of manufacture, since small irregularities in the profiles of the shaft and bearing are accommodated in the air film without appreciable effect on the position of the axis of the shaft. This reduces manufacturing costs. Further advantages are that no oil-lubrication of the bearing is necessary and that no wear of the shaft or bush can occur, since the surfaces are separated by a pressurised air-film 0·0006 in. thick.

It is offered in two forms—either as a complete instrument with its own base and column unit, or more cheaply as an accessory for use with an O.M.T. toolmaker's microscope base. *Optical Measuring Tools Ltd.*, Maidenhead, Berks.

EMD 7033 for further information

Blending Machine

A new blending machine which can be incorporated in a portable (see illustration) or wall-mounted unit is now available. This unit will bring any two liquids together and deliver them in a pre-arranged proportion through a diffuser chamber. The settling-out problems usually associated with storage vessels are thus eliminated. By using one liquid under pressure as a constant factor, the second liquid can be added to give a proportion from 5 to 40 per cent of the total output.

All the liquid-handling cylinders are in brass; the end castings, pistons and valves are in bronze, and the pipes and fittings are copper and galvanised steel. The tanks and cover are of mild steel, all welded. The inside of the tank is treated with alcohol-resisting dressing, and the outside of the tank and the non-moving parts are finished in hammer blue, with hoses in clear vision braided nylon.

This company also produces machines for blending a number of liquids, to suit individual requirements. *Suba Hydraulics Ltd.*, Limes Place, Limes Road, West Croydon, Surrey.

EMD 7034 for further information

* *Proved in Operation*

TEN TIMES LONGER

than bearings of conventional metals under the most punishing conditions

Think of the saving this entails!—not merely in replacement costs but in production time previously lost through shutdowns. Reduced friction too cuts power consumption by up to 15%, and roll neck wear is also reduced.

At the Irlam works of the Lancashire Steel Manufacturing Company Ltd., Ferobestos bearings and thrust collars are fitted on a 36" "Loewy" reversing roughing mill, and a "Sack" six-stand horizontal and vertical continuous billet mill, illustrated on left.

*Here's the proof

In a typical British application a set of Ferobestos bearings rolled over 180,000 tons of steel compared with 14,000 tons—the best performance by conventional white metal bearings. Ferobestos Bearings have given equally satisfactory service on many other kinds of rolling mills, among them plate mills up to 12 ft, slab mills up to 7 ft, section mills up to 36 inch reversing, cold sheet finishing and up to 13 high stand mills.

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FWR 48

WHAT'S NEW IN EQUIPMENT

Transistor Vibration Meter

The Transistor Vibration Meter (type 1431) is a compact and portable transistor instrument designed to measure the three important characteristics of vibration—displacement, velocity and acceleration. It is claimed that the location and source of harmful and excessive vibration can be easily discovered. The meter operates from either battery or mains supply, employing a moving-coil pick up, and weighs only 7½ lb. complete with batteries. *Dawe Instruments Ltd.*, Harlequin Avenue, Great West Road, Brentford, Middlesex.

EMD 7035 for further information

Portable Air-less Paint Sprayer

A new, fast, air-less paint spraying unit not previously shown in the U.K. was exhibited recently at the First International Industrial Finishes Exhibition at Earls Court, London. It comprises a 5-gal. paint reservoir, a 4 in. compressor with air gauge, 25 ft. of ¼ in. i.d. Teflon delivery hose, and a spray gun with a range of tungsten carbide nozzles—all mounted on a "no-tilt" dolly truck approximately 24 in. square. The unit is 54 in. high.

The 24:1 ratio compressor pressurises the paint to several thousand pounds per square inch, but delivery is said to be such that there is little overspray and no bounce-back, thus eliminating masking and cleaning-up time. It is also claimed that, through a 100 mesh stainless-steel in-line filter, there is no spattering or streaking; neither is the paint blown out of the corners or crevices of the workpiece. Less solvent is required to thin the paint, enabling a heavier coat to be applied with less tendency to sag and, in some cases, dispensing with the need for a second coat. The gun nozzles give well-defined spray patterns, thus avoiding "dusting" of adjacent areas; there is also a minimum of "haze", and ventilating equipment is seldom required. The pump's high output is said to eliminate the need for heating equipment. *Aerostyle Ltd.*, Sunbeam Road, London, N.W.10.

EMD 7036 for further information

Inverter Units

Inverter units for use in almost any situation where it is desired to operate, from direct current, electrical equipment normally requiring an alternating current mains supply, are now being produced. These units are being made in only three ratings at present, but a wider range is being developed. The first of the three units is designed to operate from 110 volts d.c., giving 230 volts a.c. at 1,200 c/s and 240 watts, and is for the fluorescent lighting of railway coaches. The second operates from any smooth 24-volt d.c. supply, giving an output of 230 volts a.c., 8 kc/s, 40 watts, and can be used in small fluorescent lighting installations. The third unit also operates from a 24-volt d.c. supply. The output, however, is 230 volts, 50 c/s at 100 watts, the unit thus being suitable for a wider range of applications demanding larger power supply. *Associated Electrical Industries Ltd.*, Aldwych, London, W.C.2.

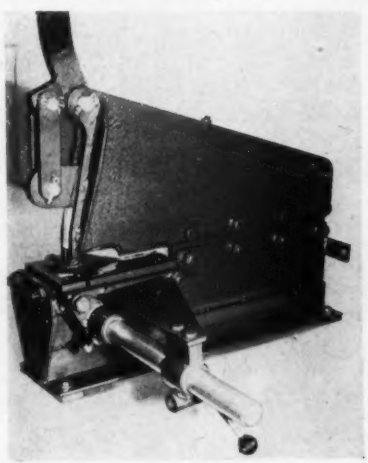
EMD 7037 for further information

New Shear for Sheet Metal

The Ferrous G.B. Sheet Shear is a revolutionary low-cost machine which is claimed to cut sheet metal accurately and without distortion, with no twisting or buckling. It is said to be ideal for slotting and notching, and has a capacity of up to ¼ in. mild or stainless steel (⅜ in. non-ferrous). Results are achieved by removing a narrow strip of metal from the waste side of the cut, which produces a perfectly clean slot and allows a sheet of any size to be fed forward freely without obstruction. Corners are cleanly removed, and marking out reduced to a minimum.

The machine is fitted with top blade and bottom die made up of three fixed blades each capable of independent grinding. *Ferrous Transformers Ltd.*, Church Road, Croydon, Surrey.

EMD 7038 for further information



New Publications and Technical Literature

Carter Gears Ltd.: 11-page brochure giving details of the new 10-h.p. AM26 hydraulic variable speed gear. Thornbury Road, Bradford, 3, Yorks.

EMD 7039

Stewarts & Lloyds Ltd.: "Industrial Pipework" is a 72-page booklet which has been compiled to assist engineers and all concerned with the design or purchase of pipework. Pipework Engineering Division, Broad Street Chambers, Birmingham, 1.

EMD 7040

Londex Ltd.: 52-page illustrated booklet of data on the company's relays and electrical automatic control apparatus. 207 Anerley Road, London, S.E.20.

EMD 7041

Miniature Bearings Ltd.: 84-page handbook and catalogue on RMB miniature ball and roller bearings, well produced and illustrated. 39 Parliament Street, Westminster, London, S.W.1.

EMD 7042

James Day (Machinery) Ltd.: Leaflet giving full details of the Sier-Bath Nyflex couplings; also a 19-page catalogue of the standard Sier-Bath range. 28 Maddox Street, Regent Street, London, W.1.

EMD 7043

Imperial Chemical Industries Ltd.: "Tomorrow's Metals Today", an 18-page brochure describing the achievements of I.C.I. Metals Division in the field of new metals. Metals Division, P.O. Box 216, Witton, Birmingham, 6.

EMD 7044

The Morgan Crucible Co. Ltd.: Issue No. 2 of "Carbon and its Uses" (a 44-page booklet), containing a further selection of articles on up-to-date applications of carbon. Central Advertising Department, Battersea Church Road, London, S.W.11.

EMD 7045

Tubewrights Ltd.: "Tubular Engineering", a 36-page well-illustrated booklet concerning the progress which has been made in the use of the steel tube as a structural member. Egginton House, 25 Buckingham Gate, London, S.W1.

EMD 7046

Stewarts & Lloyds Ltd.: "Rectangular Hollow Sections", a 39-page well-illustrated brochure covering all sizes and properties in the hot-finished welded and hot-finished seamless ranges produced by the company. Structural Steel Sales Department, Broad Street Chambers, Birmingham, 1.

EMD 7047

Camrex Paints Ltd.: 55-page booklet on Camrex industrial maintenance paints. Hudson Road, Sunderland.

EMD 7048

English Electric Valve Co. Ltd.: 12-page booklet of data and drawings on the firm's five types of high-vacuum variable capacitor. Chelmsford, Essex.

EMD 7049

Geo. Bray & Co. Ltd.: 29-page well-illustrated catalogue of the company's range of ceramic insulators. Leicester Place, Leeds, 2.

EMD 7050

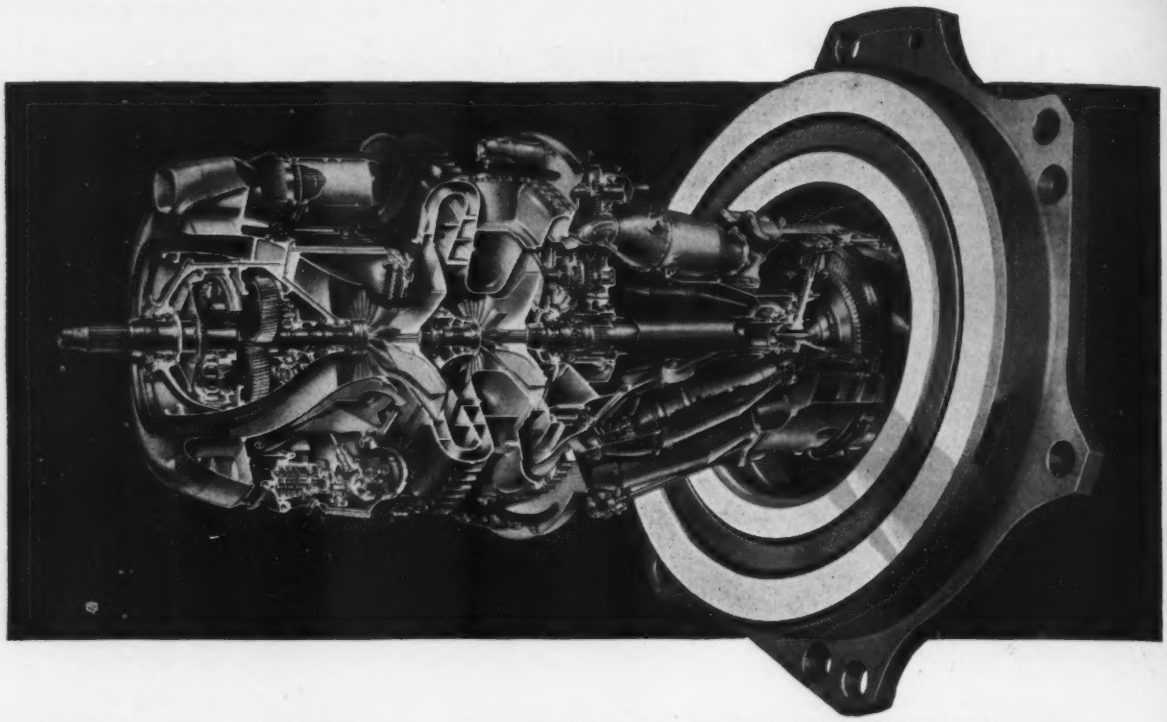
J. Smith & Sons (Clerkenwell) Ltd.: Tabulated catalogue of non-ferrous metals (in the form of rods, bars, tubes, wire, strip and blanks); also details of expanded metal, gauze, spring steel, nuts and bolts, and machinery capacity. 42-54 St. John's Square, Clerkenwell, London, E.C.1.

EMD 7051

Edgar Allen & Co. Ltd.: "Trackwork Engineering", a 282-page well-illustrated book on developments in railway engineering, free to genuinely interested railway engineers. Imperial Steel Works, Sheffield, 9.

EMD 7052

EMD 6934 for further information



HOW FBC ARE GROWING

It is years since F.B.C. first supplied bearings for the very-high-speed supercharger of the famous Rolls-Royce Merlin aircraft engines.

It was the quality of those bearings that led to the present situation, where F.B.C. are major suppliers of bearings for Rolls-Royce jet engines.

FAFNIR BEARING COMPANY LTD.
WOLVERHAMPTON

REGD. TRADE MARKS, F.B.C., FAFNIR

ABOVE
by courtesy of
Rolls-Royce Limited, the

ROLLS-ROYCE
DART
PROP-JET ENGINE

the most established gas turbine engine in airline service. Shown at the right is one of the F.B.C. bearings used on the compressor shaft: many other F.B.C. bearings are also fitted.

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FAFNIR

A REPUTATION FOR FINE QUALITY
AN INCREASED RANGE OF BEARINGS
GREATLY AUGMENTED FACILITIES

News of Industry

The European and Commonwealth manufacturing rights of the full range of Pegasus electro hydraulic servo valves, and associated electronic equipment, have been acquired by **Telehoist Ltd.**, of Cheltenham. The Pegasus valve is a high performance unit which is expected to find its greatest usage in industrial and marine applications, although at present it is specified also on aircraft and missile projects in the U.S.A.

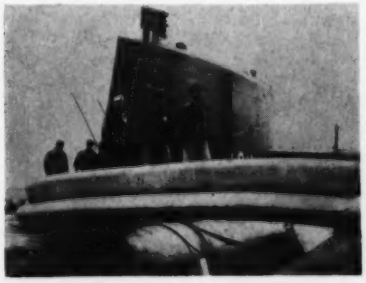
Also to be made under licence by Telehoist is the Hartmann Rol-Vane hydraulic motor, at present made only by the Hartmann Manufacturing Co., in Wisconsin, U.S.A. This device is primarily intended for use in the machine-tool field, where its ability to provide a straight-line output torque even at fractional r.p.m. is of extreme value. The Rol-Vane motor may be installed so as to be controlled by the Pegasus servo valve, which combination will provide a compact and highly efficient servo drive suitable for use in tape-controlled machine tools or constant-speed drives.

When bowling alleys were first introduced in the U.S.A., the scarcity of labour to set up the ten pins between games led to the development of automatic pin-setting machines. In Canada, where the five-pin game is played, an automatic pin-setting machine using compressed air has recently been developed, and now hundreds of such machines are in operation. One of the many technical problems to be faced was the important question of reducing the noise of exhaust air from the pin-setting machines. **Martonair (Canada) Ltd.**, of Richmond, Surrey, and **Phillips Electronic Ltd.**, of Toronto, Canada, the manufacturers of the machines, worked in close liaison on this problem, and decided to make the body of the silencers from Vyon, a permeable high-density polyethylene of medium pore size which has proved ideal for use as a filter or silencer on pneumatic equipment. Vyon effectively silences the noise from air valves, is economical and robust, and its permeable structure permits very high air flow (it is manufactured by **Porous Plastics Ltd.**).

In military operations involving infantry combat units or other ground formations, the experience is that a high proportion of casualties is attributable to mortar fire. The British Army is now to have new mobile radar equipment which will enable it to pinpoint the positions from which hostile mortars are firing. Cables and polypole couplers, manufactured and supplied by **British Insulated Callender's Cables Ltd.**, form a vital link between the radar tracking equipment and its generator, as well as between the tracker and the unit by which the tracker is operated by remote control. The cables are of multi-core plastics insulated and neoprene oversheathed trailing types specially developed for use under arduous conditions in the field. Polypole couplers with seventy-seven contacts are moulded to each cable end, thus providing extremely robust terminations in a reasonably small space. Special key-way arrangements have also been incorporated to prevent the incorrect connection of couplers.

Experience and research have shown the vital need to keep engineers abreast of news in both the technical and commercial side of their work, and *Engineering News*, the new weekly newspaper for industry, will achieve this on a world-wide front. Complementary to *Engineering Materials and Design*, it will week by week provide a comprehensive and authoritative coverage of both technical and commercial developments. Following **Heywood** policy, particular emphasis will be laid on commercial and financial news. A team of staff writers and specialist contributors will report on engineering developments at home and overseas. The first issue will be published on October 5, 1961.

The American nuclear-powered submarine *Theodore Roosevelt* has a new gang-plank, made of air-inflatable rubberised fabric, which eliminates the vibration and noises associated with conventional metal planks. Constructed by **Goodyear** in the U.S.A., the gang-plank will support 1,500 lb. It is made of Airmat and creates no storage problems, since it can be quickly deflated and easily rolled up after use.



The plank is 23 ft. long and arched, with a 2-ft. walkway, and has corrugated rubber matting cemented to its floor to provide a non-skid surface. The arch is maintained by upright beams, also made of Airmat, which, in addition, serve as sides. The floor section and each beam are separately inflated. The assembly is completed by a handrail of nylon cord supported by metal posts, which are coated with neoprene rubber. This gang-plank is unfortunately not available in Great Britain.

R. Cruickshank Ltd., industrial chemical manufacturers and suppliers of chemicals and plant used in the electroplating and metal finishing industries, have now joined the **Forestal Group of Companies.** This acquisition is part of the Forestal programme of extension into the chemical manufacturing industry. The Group's considerable technical resources will be applied to developing the range of products and technical service provided by Cruickshank.

An initial order worth £300,000 from the Lancia Motor Co., of Turin, has been placed for the new Birfield constant velocity universal joints manufactured by **Hardy Spicer Ltd.** These joints, four of which will be needed for each vehicle, were designed to meet the transmission problems of Lancia's new front-wheel-

drive car, the Flavia, which is scheduled to be produced at the rate of 1,000 a week. The first cars to use these joints were B.M.C.'s new mini-cars, and the large-scale production of these parts has meant the installation of entirely new machine tools which work automatically to a degree of precision entirely new to the transmission industry.

MEETING AND EXHIBITIONS

A course on "Design Opportunities in Timber" is to be held at the **York Institute of Advanced Architectural Studies** from September 15 to 19, 1961. The course is being organised in conjunction with the **Timber Development Association**, and is planned to give the latest information on recent international developments and design possibilities in the use of timber as a structural material, and its functional, æsthetic and economic advantages.

A course on timber engineering will also be held at the Department of Civil Engineering (University of Durham), **King's College**, Newcastle upon Tyne, from July 17 to 21, 1961. This course will include a site visit and demonstrations, as well as lectures.

The first international conference on timber engineering is to be held at the **University of Southampton** from September 18 to 23, 1961. It is being organised jointly by the University and the **Timber Development Association**. Papers will be presented to the Conference under four main headings—description, construction, design and research. The conference secretary is Dr. H. G. Allen, and requests for further information should be addressed to him at the Department of Civil Engineering, University of Southampton.

FILMS

A colour film running for 25 min., and entitled "By Precision to Perfection", has been produced by the **English Electric Valve Co. Ltd.** It commences with descriptions of various applications of the company's products, and then shows how the components are manufactured and tested. Copies of this 16-mm. sound film are available on loan to educational authorities, engineering associations and other interested bodies free of charge from the G.B. Film Library, 1 Aintree Road, Perivale, Greenford, Middlesex.

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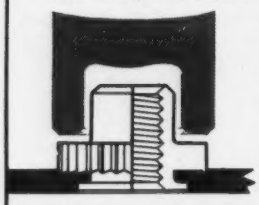
THE ROSAN PRESS NUT

does not require riveting over

The Rosan Press Nut is cheaper, easier and faster than other methods of providing tapped holes in sheet or plate. The same size Rosan Nut is suitable for any thickness of sheet. 'There is no maximum sheet thickness'.

HOW IT WORKS

Punch or drill round hole in sheet metal to specific diameter. Insert smaller flange into hole. Apply impact force to exposed edge of serrated flange of Press-Nut.



Note that impact flows sheet metal into space between flanges, locking the Press-Nut securely in place. Teeth of the serrated flange broach themselves into the parent metal preventing rotation.

Leaflet and samples sent on request to the manufacturers:—

INSTRUMENT SCREW CO. LTD.,
Northolt Rd., South Harrow, Middx.
Tel: Byron 1141

TAS/IS.17